SEPTEMBER 1953

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • NO. 9

TWO PARTS
PART 1

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Safety Program	Task Group Report
Training Courses and Certification	Committee Report

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Journal

AMERICAN WATER WORKS ASSOCIATION

September 1953
Vol. 45 • No. 9

Two Parts
Part 1

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THIS ILLUSTRATION shows the laying of cast iron pipe in the business section of a small town, which could be for water, gas or sewerage service. Such a situation calls for a pipe with proved long life to be placed beneath the costly permanent pavement. Whether in the business district, residential area or the country, cast iron pipe has established an enviable record of low cost per service year.

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AWWA SECTIONS

Sept. 21–22—Maritime Branch, Canadian Section, at Fort Cumberland Hotel, Amherst, N.S. Secretary, J. D. Kline, Chief Engr., Public Service Com., Box 574, Halifax, N.S.

Sept. 21–23—Kentucky-Tennessee Section at Hotel Owensboro, Owensboro. Secretary, J. Wiley Finney, Jr., Asst. Director, State Dept. of Public Health, 420—6th Ave., N., Nashville 3, Tenn.

Sept. 22–23—Rocky Mountain Section at LaFonda Hotel, Sante Fe. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

Sept. 22–24—Wisconsin Section at Hotel Pfister, Milwaukee. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3.

Sept. 27–29—Missouri Section at Elms Hotel, Excelsior Springs. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

Oct. 4–6—Alabama-Mississippi Section at Heidelberg Hotel, Jackson, Miss. Secretary, Charles W. White, Asst. San. Engr., State Dept. of Public Health, 537 Dexter Ave., Montgomery 4, Ala.

Oct. 11–13—Florida Section at McAllister Hotel, Miami. Secretary, William W. Aultman, Asst. Director, Dept. of Water & Sewers, Box 315, Coconut Grove Sta., Miami 33.

Oct. 14–16—Iowa Section at Russell Lamson Hotel, Waterloo. Secretary, H. V. Pedersen, Supt. of Water Works, Municipal Bldg., Marshalltown.

Oct. 18–21—Southwest Section at Rice Hotel, Houston. Secretary, Leslie A. Jackson, Mgr.-Engr., Municipal Water Works, Robinson Memorial Auditorium, Little Rock, Ark.

Oct. 22–24—New Jersey Section at Madison Hotel, Atlantic City. Secretary, C. B. Tygert, Wallace & Tiernan Co., Inc., Box 178, Newark 1.

Oct. 27–30—California Section at Palace Hotel, San Francisco. Secretary, John C. Luthin, 1113 Laurent St., Santa Cruz.

Oct. 28–30—Chesapeake Section at Hotel DuPont, Wilmington, Del. Secretary, Carl J. Lauter, 6955—33rd St., Washington 15, D.C.

Nov. 4–6—Virginia Section at Roanoke Hotel, Roanoke. Secretary, J. P. Kavanagh, Dist. Mgr., Wallace & Tiernan Co., Inc., 915 Colonial-American Bank Bldg., Roanoke 11.

Nov. 9–11—North Carolina Section at Hotel Sheraton, High Point. Secretary, E. C. Hubbard, Exec. Secy., State Stream Sanitation Com., Box 2091, Raleigh.

(*Continued on page 10*)

Coming Meetings

(Continued from page 8)

Dec. 3–5—Cuban Section at Havana. Secretary, L. H. Daniel, Baratillo 9, Havana.

1954 SECTION MEETINGS

Jan. 19—New York, in New York City
Mar. 17–19—Illinois, in Chicago
Mar. 18—New England, in Boston
Apr. 7–9—Kansas, in Emporia
Apr. 12–14—Canadian, in Toronto, Ont.
Apr. 22–23—Nebraska, in Lincoln
Apr. 22–23—New York, in Watertown
Apr. 22–24—Arizona, in Tucson
Apr. 24–25—Montana, in Bozeman
May 23–28—AWWA, in Seattle
June 16–18—Pennsylvania, in Allentown
Sept. 8–10—New York, in Montauk, L.I.
Sept. 15–17—Michigan, in Muskegon
Sept. 22–24—Ohio, in Dayton
Sept. 28–30—Wisconsin, in Green Bay
Oct. 17–20—Southwest, in El Paso, Tex.
Oct. 26–29—California, in Long Beach
Oct. 27–29—Chesapeake, in Baltimore (Tentative)
Nov. 3–5—Virginia, in Richmond
Nov. 4–6—New Jersey, in Atlantic City

OTHER ORGANIZATIONS

Sept. 28–30—New England Water Works Assn., Poland Spring House, Poland Spring, Me. Details from Joseph C. Knox, Secy., 73 Tremont St., Boston 8, Mass.

Oct. 8–9—National Conference on Industrial Hydraulics, Sheraton Hotel, Chicago. Details from Otmar E. Teichman, Conference Director, Illinois Inst. of Technology, 35 W. 33rd St., Chicago 16, Ill.

Oct. 13–16—Federation of Sewage and Industrial Wastes Assns., Municipal Auditorium, Miami, Fla. Details from W. H. Wisely, 325 Illinois Bldg., Champaign, Ill.

Oct. 19–23—National Safety Congress and Exposition, Chicago. Details from R. L. Forney, National Safety Council, 425 N. Michigan Ave., Chicago 11, Ill.

Oct. 26–29—American Public Works Assn., New Orleans, La. Details from D. F. Herrick, Exec. Secy., 1313 E. 60th St., Chicago 37, Ill.

Oct. 27–30—National Water Well Assn. at Hotel Benjamin Franklin, Philadelphia, Pa. Details from Robert R. Storm, Exec. Secy., 811 W. Springfield, Champaign, Ill.

Nov. 8–11—National Inst. of Governmental Purchasing at Netherlands Plaza, Cincinnati, Ohio. Details from Albert H. Hall, Exec. Director, 730 Jackson Pl., N.W., Washington 6, D.C.

Nov. 9–13—American Public Health Assn., Hotels Statler and New Yorker, New York, N.Y. Details from R. M. Atwater, Exec. Secy., 1790 Broadway, New York, N.Y.

1954 MEETINGS

May 4–6—American Public Power Assn., in Chicago
June 13–18—American Society for Testing Materials, in Chicago
Sept. 13–15—New England Water Works Assn., in Dixville Notch, N.H.
Oct. 11–14—Federation of Sewage & Industrial Wastes Assn., in Cincinnati.
Oct. 11–15 (tentative)—American Public Health Assn., in Buffalo
Oct. 17–20—American Society of Civil Engineers, in New York City
Oct. 19–22—Pennsylvania Water Works Assn., in Atlantic City, N.J.
Nov. 28–Dec. 3—American Society of Mechanical Engineers, in New York.

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MR. DON BURR
Assistant Superintendent

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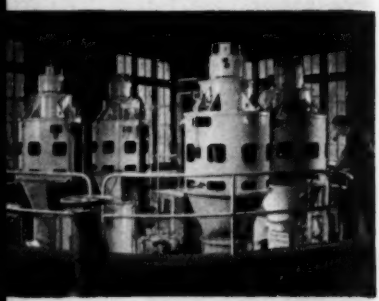
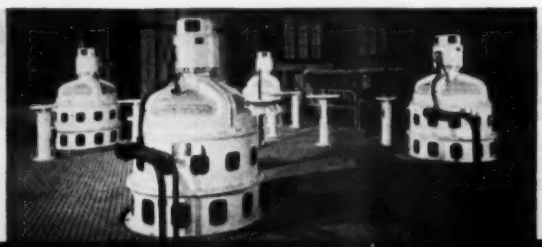
The Gary-Hobart Water Corporation operation also is unusual in that all city water comes through a Lake Michigan suction tunnel 6 ft in diameter and *three miles long.* When power fails, this moving column of water can cause a surge flooding the main pumping station.

With the original horizontal pumping units, a surge rendered motors inoperative for some time. The four new Allis-Chalmers vertical mixed flow units were made 57 ft long so that the impellers are kept submerged despite "draw down" and yet the 350 hp motors cannot be flooded. Fifteen foot extensions protect the motors for the four high head units.

When *your city* plans expansion or modernization, do as Gary and other leading cities are doing — take advantage of Allis-Chalmers experience in municipal pumping equipment. Ask for Pump Bulletin 08B6146A, containing 24 pages fact-packed with the kind of engineering data you'll want to keep handy. Just call your nearest A-C sales office or write to Allis-Chalmers, Milwaukee 1, Wisconsin. A-3994



LOW LIFT PUMPS in the 100 ft deep well at tunnel's end are 36 x 24 in. mixed flows, each rated 15,000 gpm against 50 ft head; driven by 350 hp, 720 rpm synchronous motors. Units were made 57 ft long to avoid motor flooding in case of power failure. In 1951, Gary's peak pumpage rate for one hour was 44 M.G.D.

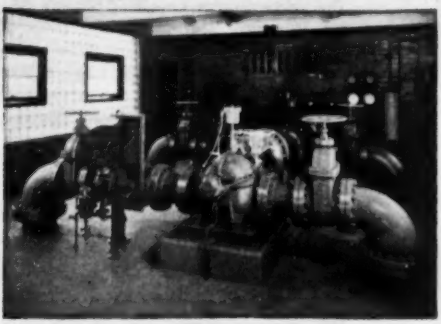


HIGH HEAD PUMPS are 24 x 18 in. centrifugals, each rated 14,000 gpm against 160 ft head; driven by 700 hp, 720 rpm synchronous motors. The high head units pump directly into the mains, operating in series with the mixed flow pumps. Special 15 ft high barrel type supports keep the motors out of flooding danger.

Growing City Expand Water Works

METROPOLITAN GARY, the planned city built on the sand dunes at the lower end of Lake Michigan. Portions of steel mills and lake are seen in distance.

GREAT FLEXIBILITY at the main pumping station is provided by the header and valving arrangement. Operation can be varied from only one high head unit in service — pumping directly from well to mains and adequate for light loads — to all eight units pumping simultaneously — adequate for Gary population doubling.



GLEN PARK BOOSTER STATION is also exclusively Allis-Chalmers. These two 12 x 12 in. centrifugal pumps are each rated 3200 gpm against 115 ft head; driven by 50 hp, 1160 rpm induction motors. To maintain constant pressure, they are automatically remote-controlled from the water tower.

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A-C ALLIS-CHALMERS

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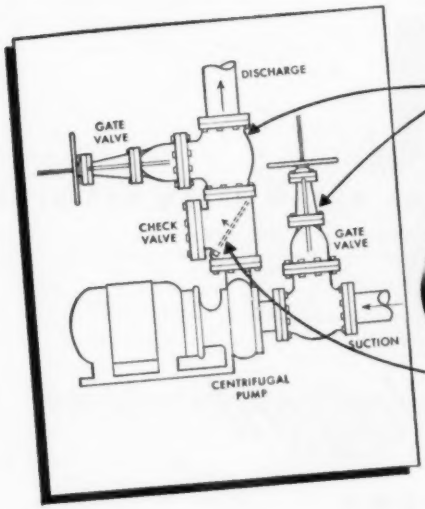

KENNEDY Fig. 0611 iron-body bronze mounted gate valve with solid wedge disc.

KENNEDY Fig 106 swing check valve. Iron-body, bronze-mounted. Available with bronze, leather or iron discs.

How proper valving assures easy maintenance of centrifugal pumping systems

In the diagram, you will note that there is a *gate* valve on either side of the pump.

On the suction side, it is connected directly with the pump. On the discharge side, the *swing check* valve should be located between the pump and the *gate* valve.

With this set-up, the flow can be readily shut off between the two gate valves to provide fast, easy repacking or other maintenance on the pump or check valve. And in a multiple pumping system, any one of the pumps can be shut down while the others continue to operate.

KENNEDY **JOB-FITTED iron-body gate and swing check valves** are ideally suited to this application. They are designed and constructed for heavy-duty service with water, oil, gas or any fluids that will not corrode bronze or iron. The rising stem on the KENNEDY outside screw and yoke gate valves tells whether valves are open or closed. KENNEDY swing check valves have readily removable cap for easy inspection or adjustment.

THE COMPLETE LINE OF KENNEDY JOB-FITTED valves and INSPECTED fittings is sold through local distributors, ready to give you fast and convenient service.

Est. 1877

THE **KENNEDY**

VALVE MFG. CO. • ELMIRA, N.Y.

VALVES • PIPE FITTINGS • FIRE HYDRANTS

Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 45 • SEPTEMBER 1953 • NO. 9

Introduction of Universal Metering at Ottawa

By W. E. MacDonald

A paper presented on Apr. 8, 1953, at the Canadian Section Meeting, Buffalo, N.Y., by W. E. MacDonald, Comr. of Water Works, Ottawa Water Works Dept., Ottawa, Ont.

THE Ottawa, Ont., water works system was first established in the year 1872. From the date of inception, up until the fall of 1952, it was the policy of the department to supply water to all consumers other than commercial under a schedule of rates based on the assessed value of the property receiving service. During the period 1919–50, however, Ottawa supplied water to several adjacent municipalities through master meters. In all of the latter municipalities, the water was fully metered and sold to the residents at varying rates fixed by the respective city councils.

The National Capital Plan, adopted in 1949, called for increasing the area of Ottawa from 6,600 acres to 30,000 acres. It was realized that the implementation of this plan would, in a very short time, tax the water works system even beyond its normal rated capacity. To meet this situation, Ottawa, the surrounding municipalities, and others represented on the Ottawa Planning Area Board engaged a firm of consulting engineers to report on water supply and sewage disposal for Ottawa and related areas. The consultants recommended the construction of a 24-mil gal reservoir, the building of large feeder mains, and the complete metering of all services. These three recommendations had previously been made by the author to the city council.

Immediately after the report of the consultants had been received, plans and specifications were prepared for the construction of the large reservoir and for the installation of the most essential feeder mains. Bids were called for and contracts awarded for major works involving an expenditure in excess of $6,000,000. Most of these large feeder main projects have now been completed, and the new storage reservoir went into service in July 1953.

Ottawa's present water purification and pumping plant has a rated capacity of 42 mgd (Imp.) but, without adequate storage, can supply only 30 mgd (Imp.) to the consumers. The new 24-mil gal storage reservoir will be sufficient merely to meet the requirements of the city during the next 3 years. Therefore, further steps had to be undertaken immediately to insure an adequate supply of water at the end of this short period.

Another important consideration was that water must be provided for a rapidly expanding city area. Reduction of water waste makes possible the extension of the system to care for an equivalent amount of new consumption without increasing present filter and pumping facilities. Before annexation, the outside-city consumers supplied by the department were 100 per cent metered. In the agreements enacted at the time of annexation of the neighboring areas it was specifically stated that the meters presently installed on all services would be retained as a first step in the eventual realization of 100 per cent metering throughout the city area. The purpose of this proposal was essentially that any further supplies made available through savings effected by meters were to be used for new consumers served by new water main extensions.

Immediately after annexation, however, urgent requests were made by the elected representatives for removal of all the meters in the new wards, which were, of course, totally metered. These elected officials demanded that the residents of the recently annexed areas be accorded the same treatment as the owners living in the older wards of the city. This strong and vigorous agitation continued for 2 years.

On Oct. 6, 1952, the author presented an official report to the city council setting forth the relationship between consumption demands for filtered water and supply facilities. This report referred to the present inequitable rate structure as well as establishing the following pertinent facts about the water supply of the capital city:

1. The Water Works Department, in recent years during times of peak consumption have not been able to meet the domestic and commercial demands plus the water required by the Canadian Fire Underwriters Association for fire extinguishment.
2. To alleviate this situation, it was necessary for the Water Works Department to inaugurate a plan whereby lawn sprinkling to all properties was prohibited 3 days per week.
3. The new Carlington Heights Reservoir was recommended and is being constructed to provide storage of filtered water to meet emergencies and to augment the supply from the Filter Plant during periods of excessive demand.
4. Surveys of population and consumption indicate that the new reservoir will greatly augment the supply and maintain pressures for fire extinguishment during peak periods for the next 2 or 3 years.
5. The same surveys show that, without metering, within a period of 5 years the estimated demand for filtered water, even with the reservoir, will be in excess of the total plant facilities.

The situation was becoming critical and had to be met by the adoption of either one of the following policies: [1] the construction of additional filtration and pumping plant facilities, at an estimated cost of approximately $5,000,000; or [2] the installation of

total metering on all services, at an estimated cost of $1,250,000.

Many municipalities in the past have given little thought to the subject of complete metering as long as the supply exceeded the demand, but, when the demand has begun to approach the capacity of plant facilities, the authorities, from an economic point of view, have had to give serious consideration to universal metering.

Reasons for Metering

There are two reasons for the use of meters: [1] selling water through meters is the only logical and fair way of conducting the business, the only way that does not result in gross inequalities and discrimination against some of the takers in favor of others; and [2] it is the only practical method yet found for restricting excessive waste. The first reason is the one that in the long run is controlling. It is unanswerable. In itself, it is a sufficient reason for the adoption of the meter system. As a practical matter, however, under the conditions of the water works business as they have developed in Canada and in the United States in the last 40 years, the need for stopping waste has been more important and has more often led to the installation of meters.

When a water works system is first installed, all the plumbing fixtures in houses are new and are, in general, reasonably tight; people will ordinarily draw only the amounts of water that they need, and waste is comparatively small in amount. In time rust, corrosion, the hardening of rubber parts, and other changes result in leakage from plumbing fixtures. Small leaks running constantly make little impression on people who do not realize their significance. Eventually people become accustomed to the waste of water in their houses and grow indifferent to it. It is the experience of American cities where the meter system has not been used that the consumption always increases more rapidly than the population. It may be a long time before the output becomes double the legitimate use, but, after that point has been reached, the rate of use accelerates until three-quarters of all the water that is furnished is wasted. The only limit to the rise is due to the fact that a time comes when the new works required to supply the ever-increasing waste become so large and cost so much to build that the burden cannot be further borne, and a better method is adopted.

A prejudice against the use of meters often arises from the thought that people will not be able to use as much water as they desire without making excessive payments for it. There is also the feeling that, if the consumption of water in the city should be reduced to one-half or one-fourth of the present figure, each person would have to get along with one-half or one-fourth as much water as he now uses. These assumptions are not even remotely true. The majority of people are reasonably careful in the use of water and do not waste excessive amounts. It is the minority who, through carelessness or willful waste, discharge water into the sewers in large quantities and increase enormously the amount of water that must be provided, consequently raising the cost of water for all the people.

At present the loss inflicted by the careless or wasteful is borne by the whole city. If a meter is put on every service, the people who waste water

will have to pay for it. Others will be relieved from the burden and the cost of water to them will be materially reduced. The cost to the people who are now wasting water will also be reduced, if they are willing to learn by experience, as nearly all of them will, that they cannot waste water without paying for it.

The introduction of meters has been an unqualified success in checking waste. When water is measured and all that is used or wasted is paid for, the quarterly bills are effective reminders of the need for tight plumbing. People cease to be indifferent to continuous flows of small quantities. Even the plumbers learn in time; the standards of plumbing in cities where the meter system has been in use for some time are higher than elsewhere. The general use of meters has been universally satisfactory and has fully justified all the expense and trouble of their adoption.

Equity of Rates

The present water rate structure at Ottawa is, in the author's opinion, one of the most inequitable in Canada. The rates are not based on the price of the commodity as supplied to the consumer but in accordance with the assessed value of his property. Installation of meters on typical residential services has definitely shown the inequalities which exist at present and would be corrected under a meter program.

The main principle involved in such metering is that of payment by the consumer in direct relation to the quantity of water taken. The installation of water meters is the first step in establishing this desirable condition; the system of water rates would also have to be further revised to remove certain irregularities that derive from the inclusion of the costs of providing water for fire protection in the meter or quantity rate. Not only should a new rate structure separate payments for the two functions of the water department, but, with completion of the meter installation program, establishment of a lower minimum rate, consistent with good sanitary conditions, should also enable the careful water user to obtain a commensurate reduction in his water bill. The careless user should pay for excessive use of water, but, on the other hand, the careful consumer should obtain a maximum saving consistent with the financial requirements of the department.

Restriction of Excessive Waste

In the United States, official records show that, where the water supply has been fully metered, tremendous savings in consumption of water have been effected. Of seven cities, ranging in population from 175,000 to 300,000, which are totally metered, the average consumption is only 82 gpcd (Imp.). Many of these cities have large industries.

In Canada, of 50 municipalities where meters are installed on an average of 24 per cent of the services, the consumption is 133.9 gpcd (Imp.). In another group of 21 Canadian municipalities, with an average of 96 per cent of services metered, the consumption is 79 gpcd (Imp.).

Adoption of Program

The official report recommending complete metering of all services was presented by the author to the mayor and members of the Ottawa Board of Control on Sept. 8, 1952. The report

was enthusiastically received, particularly by the mayor, who during the past 2 years had been a strong proponent of universal metering, but there was considerable opposition from one or two board members. The report was discussed at several meetings of the board and very little progress was made in securing unanimity of the separately to the board of control. It was pointed out that the present Ottawa plant would have sufficient capacity to meet a substantial increase in population under a program of total metering, continuation of the present lawn-sprinkling restrictions, and strict adherence to the present annual leak detection survey. It was further em-

TABLE 1

Estimated Cost of Metering Entire City

Meter Size *in.*	No. of Services*	No. of Services Metered	No. of Services to Be Metered	Cost of Meter $	Installation Cost $	Total Cost $
⅝	33,470	5,149	28,321	21.70	7.50	826,973
¾	2,453	1,106	1,347	32.57	7.50	53,974
1	774	522	352	47.77	7.50	13,928
1¼	65	20	45	49.00	12.00	2,745
1½	203	200	3	86.85	12.00	296
2	403	300	103	130.28	12.00	14,655
2½	2	0	2	130.28	12.00	285
3	146	110	36	324.70	300.00	22,489
4	97	64	33	541.20	315.00	28,255
5	9	0	9	541.20	315.00	7,706
6	195	53	142	1,188.00	350.00	218.396
8	23	19	4	1,782.00	400.00	8,728
	37,840	7,543	30,297			1,198,430
Less cost of metering fire services (not considered advisable)						48,430
						1,150,000
Plus estimated cost of extensions to buildings, testing equipment, trucks, new office equipment, etc.						100,000
					Total	1,250,000

* As of Dec. 31, 1951.

members. Therefore, it was proposed by the mayor to invite both the author and the consulting engineer who had prepared the 1949 report previously mentioned to address a meeting of the board of control, with reporters from the three local newspapers present.

This arrangement was carried out and detailed reports, both recommending total metering, were presented phasized that, under a complete metering program, if and when additional pumping and filter plant facilities are required, one-third less capacity would be needed than if the city were not further metered. This fact would undoubtedly be the means of saving several million dollars in future plant extensions. Extensive accounts of this meeting were printed in the local pa-

pers, all of which published strong editorials in favor of universal metering.

Pending the official meeting of the city council, members of the water department's engineering staff were invited to speak before the Board of Trade, the Property Holders Assn., and the various service clubs. In practically every instance, prior to adjournment of the meeting, a resolution was prepared and forwarded to the scheduled meeting of the city council.

During the same interval, the mayor prepared and personally delivered many radio addresses over two of the local broadcasting stations. These were very favorably received by the public, as evidenced by the large number of taxpayers who attended the council meeting on universal metering. The final vote, taken after considerable discussion, resulted in a very large majority in favor of complete metering of all water services in Ottawa.

Meter Settings

Immediately after the council had approved the policy of universal metering, the water department undertook an intensive study of the various methods of meter installation, particularly for the smaller sizes, with a view to determining the most efficient and economic method. The cost estimates shown in Table 1 were based on the regular method of installation (Fig. 1). For a galvanized-iron service, the cost of installing a ¾-in. meter by this method averaged $6.71, comprising $1.87 for material and $4.84 for labor. An average of six such meters could be installed daily.

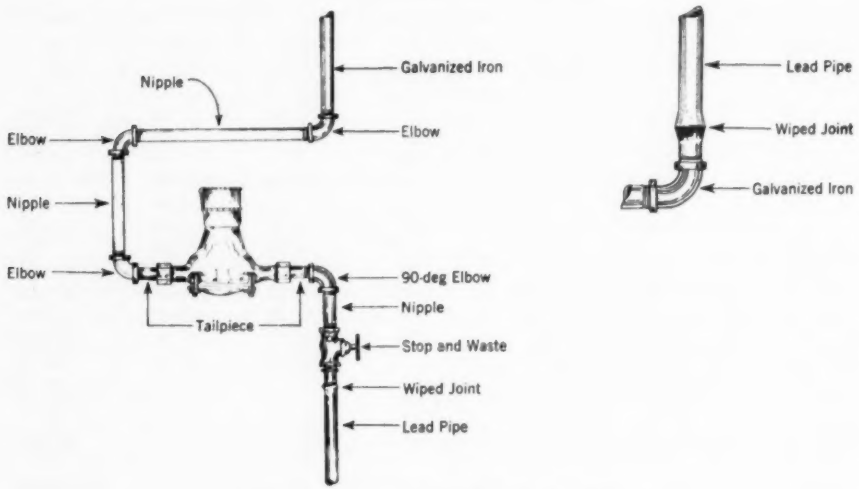

Fig. 1. Conventional Meter Setting

The diagram shows the conventional method of meter setting for galvanized-iron or copper services.

The labor cost using the conventional method was considered too high. After intensive research, the author designed a new type of meter setting, as shown in Fig. 2. This device is now available in both Canada and the United States and is being manufactured under patents pending in both countries. The new meter setting is entirely different from any other on the market and will permit substantial cost savings in the installation of ⅝- and ¾-in. meters. For a ⅝-in. meter on iron pipe, the average installation cost is $4.41. Of this amount, $1.99 is for material and $2.42 for labor. Even lower costs can be achieved on copper services. An average of twelve meters can be installed daily by the new method.

Installation Program

Before proceeding with the program, the city prepared plans and specifications and invited bids covering the installation of small-size meters. The bids received ranged from a high of $25.00 to a low of $6.00 per installation, exclusive of materials. All were rejected and the water department has undertaken the complete installation of approximately 30,000 meters in 2 years. The work has commenced and excellent progress has already been made in maintaining a monthly quota of settings. The cost records carefully compiled to date indicate that the city, mainly owing to the new type of meter setting, will be able to save more than $60,000 in the installation of small-size meters.

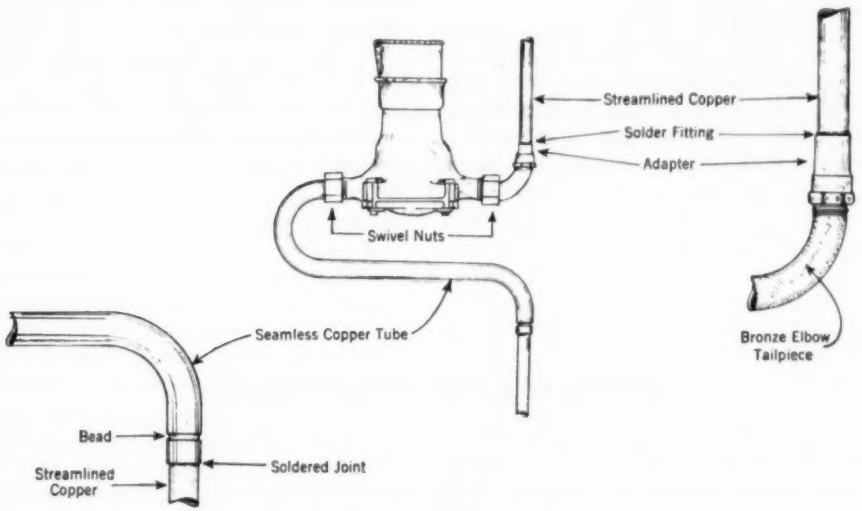

Fig. 2. MacDonald Meter Setting

The MacDonald meter setting for copper services is illustrated. It is equally adaptable to galvanized-iron pipe. The seamless copper tube has an OD of 0.750 and a wall thickness of 0.062 in.

During the 2 years it will take to complete this program, it is planned to read the meters regularly, but bills for excess water will be rendered only for the summer quarterly periods of 1953 and 1954. No other excess-water charges will be made on metered consumption until 75 per cent of all the residential properties have been metered.

Proposed Meter Rates

The water department is now planning the inauguration of a new rate schedule. In the author's opinion, an adequate schedule cannot be established until the entire city has been fully metered and the exact loss in the distribution system accurately measured. As soon as this has been achieved, the department plans to adopt a modern rate schedule based on:

1. The establishment of a service charge.
2. The fixing of a rate covering fire protection charges on all properties.
3. The establishment of a rate for water per 100 cu ft, with provision for minimum quantities.

It is the author's desire that the new rate schedule should be strictly in accordance with the reports and recommendations of the AWWA Committee on Water Rates.

Quality of Public Water Supplies

A series of U.S. Geological Survey reports on "The Industrial Utility of Public Water Supplies," just completed, provides brief information for water users on the ownership, source of supply, treatment processes, and storage facilities of the larger water systems in the United States during 1952, as well as detailed chemical analyses of both raw and finished waters. Until a consolidated report for the entire country is prepared, the data may be obtained from nine separate circulars (listed below), available without charge from the U.S. Geological Survey, Washington 25, D.C.

Circular No.	Region	States Included
197	East South-Central	Ala., Ky., Miss., Tenn.
203	Mountain	Ariz., Colo., Idaho, Mont., Nev., N.M., Utah, Wyo.
206	West North-Central	Iowa, Kan., Minn., Mo., Neb., N.D., S.D.
221	West South-Central	Ark., La., Okla., Tex.
232	Pacific	Calif., Ore., Wash.
253	East North-Central	Ill., Ind., Mich., Ohio, Wis.
269	South Atlantic	Del., Fla., Ga., Md., N.C., S.C., Va., W.Va.
283	Middle Atlantic	N.J., N.Y., Pa.
288	New England	Conn., Me., Mass., N.H., R.I., Vt.

Water Quality Yardsticks

By W. L. Mallmann

A paper presented on May 12, 1953, at the Annual Conference, Grand Rapids, Mich., by W. L. Mallmann, Prof., Dept. of Bacteriology and Public Health, Michigan State College, East Lansing, Mich.

PERIODICALLY the question arises whether a new yardstick for measuring the sanitary quality of water is needed. The question is well taken because it emphasizes the desirability of determining whether changes in operation or standard of quality of finished water warrant changes in methods of evaluation. The mere fact that the question is propounded does not imply that changes are imperative or even necessary. It does mean, however, that the present status of measurements of sanitary water quality should be examined and placed in perspective.

The bacteriological procedure presented in *Standard Methods for the Examination of Water and Sewage* (*1*) and the quantitative standards formulated by the U.S. Public Health Service (*2*) are predicated upon the detection of the coliform organisms. When the coliform tests were first formulated, it was supposed that these organisms occurred only in the intestinal tract of man and animals and, consequently, that their presence in any water supply definitely indicated sewage contamination. Early workers applied the test to all water, rural sources as well as municipal supplies. By means of this test, water supplies were readily separated into two groups: those badly contaminated and those free, or at least relatively free, of contamination. Although the test was applied to rural well supplies, emphasis was placed upon the checking of municipal waters. As improvements were made in methods of water purification, the test was used comparatively, to show differences in the coliform numbers in raw and treated waters.

Along with improved purification procedures, refinements and simplification of the coliform test have also been made. Although the coliform group consists of two principal species, *Escherichia coli* and *Aerobacter aerogenes*—the former predominantly of fecal origin and the latter primarily of nonfecal origin—the present coliform test includes both. The origin of the test organism has been ignored completely in the present standard procedure because the test was designed for municipal waters and a complete absence of any member of the coliform group is desired in 50 ml of water tested.

The past 40 years have seen an increase in the strictness of bacteriological standards. Coliform organisms must now be absent in five 10-ml portions (instead of five 1-ml portions as previously), with a tolerance of not more than 10 per cent positive 10-ml portions per month in a municipal

supply. These standards have been raised for two reasons: because greater safety was desired and because better purification techniques made it easier to attain high standards.

It is true that the maintenance of present standards in municipal supplies gives a safe water. There have been no epidemics of typhoid fever or other enteric diseases traceable to waters continuously meeting these standards. The fact that the standards have resulted in safe water over a period of many years indicates definitely that there is no need to raise them further, although purification procedures would easily permit a decreased tolerance in coliform organism numbers.

It should be clearly kept in mind that the present standard is one of attainability. The fact that present purification methods permit municipal plants to maintain, without hardship, a standard of not more than one coliform organism per 100 ml of water does not argue that a greater tolerance would result in a disease hazard. Indeed, a much greater tolerance could probably be adopted without danger, but the substantial safety margin provided by present standards is desirable.

Free residual chlorination introduced a considerable increase in that safety margin. In Detroit, prior to the establishment of this procedure, the finished water frequently showed false positives in the presumptive test using standard lactose broth. According to unpublished data from the Michigan Dept. of Health, in January 1946, at the Detroit Springwells plant, 930 10-ml portions yielded 136 false positives. No coliform organisms were detected during the entire month. In January 1947, when free residual chlorination was practiced, only one false-positive tube was obtained out of 930 10-ml portions examined. As usual, no coliform organisms were detected.

These data indicate the marked increase in the safety margin that can be attained by the use of free residual chlorination. Even the spore-bearing gas producers that survived chlorination prior to the maintenance of free chlorine residuals in the water supply have been destroyed. Free chlorine in a water means less taste and odor, so, from the standpoint of good operation, the increased consumption of chlorine is justified even without consideration of the fact that the sanitary safety margin is increased.

Culture Media

Current bacteriological standards are easily attainable and their maintenance results in a safe water. Consequently, there appears to be no reason either to increase or to decrease these standards.

The present procedure for the detection of coliform organisms in water by the use of lactose broth in the presumptive test and the use of either EMB agar or BGB as a confirmation test has produced satisfactory results as measured by water quality. In the author's opinion, however, considerable improvement of media and simplification of test procedures are possible.

In 1941 Mallmann and Darby (*3*) introduced a new medium, called lauryl tryptose broth, for the presumptive test. This medium was designed in the laboratory to grow coliform organisms in greater number and more rapidly, so that gas would appear in the inverted vials in the tubes at an earlier time. Besides, by the addition of lauryl sulfate, organisms responsible for false positives were suppressed, thus decreasing the number of con-

firmations in BGB and EMB agar. In waters where false positives are frequent—at Detroit, for example—this medium saves considerable work. Occasionally, false positives may be obtained with lauryl tryptose broth but to a much more limited degree than with lactose broth.

Lauryl tryptose broth is a more sensitive medium than is lactose broth. McCrady (*4*) observed an increased sensitivity in lauryl tryptose broth for all waters (Table 1). He stated:

TABLE 1

Sensitivity of Lauryl Tryptose Broth

Type of Water	Positive Completed Tests (Lactose Broth = 100) *per cent*
Raw	105
Unfinished	106
Finished	106
Swimming pools	113
Wells and springs	117
Sea	125
Miscellaneous sources	137

"These figures do not indicate much advantage, as regards positive complete confirmation, in substitution of [lauryl tryptose] broth for lactose broth in the examination of waters from purification plants, but it must be remembered that fewer positives had to be confirmed when [lauryl tryptose] broth was employed." It may be concluded that this medium is an improvement over the standard lactose broth.

Coliform Differentiation

The coliform group is not a certain measurement of the sanitary quality of water, because the origin of those organisms is not necessarily confined to the intestine of man and animals. There are definitely saprophytic forms capable of a free existence under environmental conditions wholly different from their usual habitat in the intestines. Coliform organisms may be forms that have adapted themselves to a new environment or they may be free-living forms that enter water from soil.

Many papers have indicated that the so-called intestinal *Esch. coli* can be differentiated from coliform organisms of nonintestinal origin. Discussion has been largely academic and has usually been confined to laboratory studies with cultures whose history of origin is vague, or at least questionable. For example, based on the classification of Stuart and others (*5*), the present author has isolated so-called fecal strains from sources where the existence of fecal strains would be difficult to explain. It is impossible to refute the statement that these organisms originated in the intestines, but it is easily proved that their existence in deep wells and other unpolluted sources indicates that they have adapted themselves to their new habitat over long periods and their sanitary significance has completely disappeared.

Assuming that coliform organisms, including the so-called fecal types, can adapt themselves to a free existence in water supplies, it is necessary to employ supplemental criteria if they are to be used as indicators of pollution.

Presence in Unpolluted Water

It has been demonstrated that coliform organisms may be present in water uncontaminated by sewage and also that an increase in population may occur. An excellent example was reported by Gowdy (*6*) at Los Angeles.

The water is impounded in seven successive reservoirs in its travel of 175 miles during a period of 5 months. The water flows through conduits for most of the journey, and the open reservoirs are located in desert country devoid of runoff or human contamination. Table 2 shows the coliform indexes for this water.

It will be noted that a marked fall in coliform organisms and *Esch. coli* occurred in the Haiwee Reservoir, but a gradual increase appeared from this point on as the water progressed from one reservoir to the next; there was also an increase in the conduits between reservoirs, where there was no possible contamination. There was a rise not only in the total number of coliform organisms but also in the *Esch. coli* index up to the Lower San Fernando Reservoir (from 4.7 to 28.6). These figures are highly significant, as they represent an average for 5 years.

TABLE 2

Coliform Organisms in Impounding Reservoirs

Location in Reservoir	Coliform Index	*Esch. coli* Index
Inlet, Haiwee	86.0	15.3
Outlet, Haiwee	9.2	4.7
Inlet, Fairmont	19.5	8.8
Outlet, Fairmont	23.5	13.7
Inlet, Dry Canyon	26.5	16.7
Outlet, Dry Canyon	31.9	17.2
Outlet, Upper San Fernando	47.9	28.6
Outlet, Lower San Fernando	26.3	26.5
Outlet, Stony Canyon	7.3	7.3
Outlet, Hollywood	7.6	7.6

If a water with a coliform index in excess of 1 is unpotable, this supply is unsafe and a potential source of typhoid bacilli and other waterborne pathogens, although a careful survey of the aqueduct area brought to light no evidence indicating fecal contamination. Presumably, this supply should be a perfectly safe source of water without treatment in spite of the fact that it sometimes shows an average coliform index of 47.9, as determined by standard methods of analysis. (The author wishes to emphasize that he makes no such recommendation, as he firmly believes that all surface waters, irrespective of their sanitary condition, should be treated.) These data, which are representative of a number of sets of data available to the author, imply that low-level coliform indexes in a stream or lake may not be indicative of sewage pollution even in relatively low concentration.

Effect of Temperature

It may be pointed out further that, in warm weather, unpolluted streams have relatively high coliform indexes, undoubtedly a result of cell multiplication. This is shown clearly in the 133-mile aqueduct that connects the Haiwee and Fairmont reservoirs of the Los Angeles water supply. The aqueduct is covered and is securely protected against the entrance of storm waters. There is no possibility of either human or animal contamination. The monthly percentage of samples with one or more positive 10-ml test portions is given in Table 3.

The effect of temperature is also shown in a shallow lake with a high biological activity that was examined by Mallmann and Sypien (*7*). Samples were collected from the center of the lake during the months of June, July, and August. The lake is approximately 1 mile long and ¾ mile wide, with a water depth of approxi-

mately 10 ft at the center. Both *Esch. coli* and *Aer. aerogenes* were found. The figures in Table 4 show that high coliform indexes may occur in the absence of sewage contamination in lakes rich in organic content.

Ohio River Studies

Turning to the behavior of coliform organisms in water in which sewage contamination is known to exist, the classic studies of Frost and Streeter (*8*) show very clearly that the self-purification of the Ohio River can be measured by the use of the coliform index. Briefly, they found that, in warm weather, the number of coliform organisms will be reduced to 10 per cent of the initial number in the course of 2 days and that the reduction will continue at the same rate until approximately 1 per cent remains after 4½ days. Eventually a fairly uniform index is reached which will become more or less typical of the stream and begin to approach the condition existing in a clean stream. Inasmuch as enteric pathogens have a death rate in water somewhat comparable to coliform organisms recently discharged from the intestines, the coliform index in such streams as the Ohio becomes a fair yardstick for measuring the degree of sewage contamination.

TABLE 3

Seasonal Variations in Coliform Population

Month	Positive Samples *per cent*
January	0.0
February	6.7
March	0.0
April	18.7
May	21.0
June	26.3
July	40.0
August	15.8
September	37.5
October	40.0
November	5.5
December	10.5

Eijkman Test

Frequent attempts have been made to separate the coliform organisms on the basis of origin. In general, it has been assumed that *Esch. coli* is of intestinal origin and *Aer. aerogenes* of soil origin. This distinction is true in the sense that the former predominates in fecal matter and the latter in unmanured soils. An attempt to sort out fecal and nonfecal coliform organisms was made by Eijkman (*9*) on the assumption that organisms accustomed to growing at body temperatures would have higher maximum growth temperatures than those used to growing at lower temperatures in soil. He reported that coliform organisms growing at 45.5°C were of fecal origin and that coliform indexes obtained at this temperature represented true sewage contamination.

TABLE 4

Coliform Indexes in Lake With High Organic Content

Sample No.	Indicated Coliform Index
1	8
2	110
3	10,000
4	10,000
5	100
6	6
7	100
8	10
9	10

An opportunity to measure the value of this test along with others developed by the author was presented by a 2-year study of sewage contamination of a bathing beach on Lake Erie. Com-

parisons involving lactose broth, lauryl tryptose broth, and the Eijkman test were made. To interpret the data better, it is necessary to describe the bathing beach and the surrounding area in some detail.

The beach is located on the west side of Lake Erie, just north of the Ohio border. The Raisin River, which empties into Lake Erie at the south end of the beach, carries the primary effluent from Monroe, Mich., and also considerable industrial wastes and sanitary sewage from a number of paper-manufacturing plants below the city and near the mouth of the river. The river is heavily polluted. The bathing area starts approximately 1 mile north of the mouth of the river and is approximately 1 mile in length. Slightly over ½ mile farther down the beach, a small creek empties into the lake. There is no sewage pollution in this stream.

Samples were collected approximately ¼ mile off shore, where the water is approximately 10 ft deep. Samples were also taken near the shore, in water approximately 3 ft deep. Because the latter gave results similar to those obtained from deep areas, only the deep-water samples will be discussed. Samples were collected weekly throughout the summer months of 1944 and 1945. In 1944 sampling was started May 5 and stopped Oct. 3. In 1945, sampling was started July 18 and continued until Oct. 10.

The comparative results for lactose broth and lauryl tryptose broth, shown in Table 5, indicate, as would be expected from previous studies, that the older, attenuated coliform cells grow out better on lauryl tryptose broth. The data show definitely that, as the pollution gradually moves down the beach, a marked diminution of coliform organisms occurs. This fact is indicated by both media, but the number recorded with lauryl tryptose broth is proportionately higher than that with lactose broth at the station farthest away from the source of pollution.

When isolations were made from EMB agar plates, the ratio of *Esch. coli* to *Aer. aerogenes* did not change materially as the sewage pollution progressed along the bathing beach. Inasmuch as a marked reduction in total bacterial population occurred, indicating good self-purification of the water, it might be expected that a greater fall in so-called fecal coliform organisms would result, so that the proportion

TABLE 5

Comparison of Lactose and Lauryl Tryptose Broths

Distance From Mouth of Raisin R. *miles*	Coliform Index			
	1944		1945	
	Lactose	Lauryl Tryptose	Lactose	Lauryl Tryptose
0	17,000	17,000	22,000	28,000
1	760	1,700	1.300	3,600
1½	440	1,100	360	460
2	200	228	100	360
2½	220	436	100	460

of *Aer. aerogenes* would increase as purification progressed.

The comparative results for lactose broth and Eijkman tests are given in Table 6. Bacterial populations decreased on both media as the sewage pollution moved away from the source. Both indexes decreased at approximately the same rate, as indicated by the ratio between the two media at the various sampling points. The data show that the Eijkman test does not yield any additional information on the degree or type of pollution. All that is indicated is the fact that the majority of the coliform organisms present, even in the heavily contaminated area, fail to grow at 45.5°C. The data show that the organisms capable of growth at 45.5°C survive exposure in proportionately the same numbers as those capable of growth at 37°C.

Need for Research

These studies confirm many observations by others that no reliable method of differentiating fecal and nonfecal coliform organisms exists. Such a method is definitely needed, particularly for rural well supplies, which are sometimes condemned owing to the presence of nonfecal coliform organisms. Further research utilizing new methods of differentiation employed in typing *Salmonella* might be productive.

As stated earlier in this paper, the coliform test using the USPHS standards is not always applicable to rural water supplies because the coliform organisms are not comparable in origin or numbers to those appearing in municipal waters from sewage-contaminated sources. In Michigan, where ground waters are abundant, there are few areas where coliform-negative waters are not readily accessible in wells from 25 to 150 ft in depth. When waters containing nonfecal coliform organisms are condemned on the basis of the present standard procedure, no real hardship is inflicted by the necessary relocation or deepening of the well. The requirement of a water with a coliform index of less than one is at present good public health policy in Michigan.

Not all areas of the United States are as fortunately situated geologically as Michigan in regard to ground waters. In some areas, it is particularly difficult to obtain water free of coliform organisms. A careful sanitary engineering survey of the coliform-contaminated well often fails to reveal any mechanical defect in the well or any contaminating source in its vicinity. Although numerous rural water supplies contain coliform organisms, there is frequently no epidemiological evidence of enteric disease that might be traced to water supplies.

The author believes that research should be initiated on the bacterial flora of rural water supplies: [1] to determine the significance of the coliform test; and [2] to develop new methods using either coliform organ-

TABLE 6

Comparison of Lactose Broth and Eijkman Tests

Distance From Mouth of Raisin R. *miles*	Coliform Index	
	Lactose	Eijkman
0	17,000	870
1	7,600	44
1½	440	34
2	220	20
2½	220	7.6

isms or other organisms that might indicate fecal contamination.

The author and his coworkers have been engaged for the past two decades in research on the incidence of streptococci in swimming pools. In 1938 Mallmann (*10*) reported on streptococci as indicators of swimming pool pollution. Buccal contamination of swimming pool waters was believed to be equal to, if not of greater significance than, fecal contamination. Inasmuch as streptococci were found to have a greater resistance to chlorine than coliform organisms, the maintenance of a pool with a minimum content of streptococci (MPN 2–6) was set as a goal of attainability. It may be of interest to report that the nine pools in the Lansing, Mich., area examined routinely by the author have met this standard for the past 20 years.

In 1950 Mallmann and Seligmann (*11*) reported on a new medium, dextrose azide broth (Rothe), for the detection of streptococci in water and sewage. This medium, which has been used routinely on all pool samples since 1950, is selective for streptococci and yields a higher number from samples tested than *Streptococcus faecalis* (SF) broth (*12*), azide broth (Mallmann) (*13*), or lactose broth.

Litsky, Mallmann, and Fifield (*14*) report a new medium, ethyl violet azide broth, for the detection of enterococci. It serves as a confirmatory medium for checking streptococci detected in dextrose azide broth, which is used as a presumptive medium. These media have yielded much higher enterococci indexes than SF medium (*12*) and Sandholzer and Winter's media (*15*).

The use of enterococci as detectors of fecal contamination, employing these media, offers many possibilities for measuring sanitary quality in numerous instances in which the coliform test has not been satisfactory. Only research using these media will demonstrate whether they may supplant or supplement the coliform test.

Summary

1. The coliform test is a satisfactory method of measuring the sanitary quality of municipal water supplies.

2. The use of fecal type coliform organisms for measuring the sanitary quality of water is not applicable as yet, owing to the lack of a satisfactory method of identification.

3. A new yardstick for measuring the sanitary quality of rural water supplies is needed. The absence of coliform organisms in rural water supplies indicates a satisfactory water, but their presence does not necessarily indicate an unsafe supply.

4. The use of streptococci for measuring the sanitary quality of swimming pool water is suggested.

5. New media for the detection of enterococci that yield higher incidences than media previously proposed offer a new yardstick for measuring fecal contamination in instances in which coliform tests have been unsatisfactory.

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Discussion

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The coliform test has been in use for more than 60 years as an indicator of the pollution of water. The technique has undergone many changes and modifications during that time. Originally it was concerned only with the detection of the "fecal" members (such as *Esch. coli*) of the coliform group, but, as experience in water examination grew and as newer and better methods of water treatment were developed, the procedure was altered until it is now a much more inclusive test and covers all of the members of the coliform group.

Trends in the United States have been in quite a contrary direction to those in other parts of the world, particularly Europe, where only "fecal" members of the coliform group are still used as an indication of water quality, the presence of other members (such as *Aer. aerogenes*) being disregarded. The net result is that standards of water quality in the United States, as established by the U.S. Public Health Service, are much more severe than elsewhere. It should be borne in mind, however, that American standards are based on what it is both technically and economically possible to achieve in the United States. In many other countries, such high standards could not be readily met, chiefly because the types of treatment economically possible probably would not result in production of a water with an MPN index of less than one coliform organism per 100 ml. Methods employed in the United States are an excellent check on water treatment possible there and on rigid standards of water quality. They are not necessarily the sole indicator of the ultimate safety of water for dietetic purposes, because coliform organisms may be present in water without danger

that enteric disease will develop in the consumers.

With the gradual disappearance of typhoid fever and similar waterborne enteric diseases in this country, there arises the question of the possible presence of other infective agents in water, not revealed by the current standard bacteriological techniques that have proved so excellent a measure of sewage pollution.

The development of the streptococcus test, discussed by the author, is a further step forward in the appraisal of water quality. If only sewage pollution were involved, perhaps such refinements would not be necessary. In bathing waters, however—especially in swimming pools—fecal streptococci are undoubtedly a more significant indicator of pollution than is the coliform group of bacteria. Thus, the information on water quality furnished by the quantitative results of a fecal streptococcus test is certainly essential for the control of bathing waters.

Virology

Trends in public health are very definitely in the direction of studies in virology and modes of transmission of diseases caused by the virus type of microorganism. It is well known that many kinds of viruses inhabit the intestinal tract; they must, therefore, be present in sewage and would appear in sewage-polluted water, whether the supply is intended for domestic use or as bathing water.

Unfortunately, present information on viruses does not permit determining whether these intestinal inhabitants remain in the water longer than the coliform group or whether they are subject to destruction by the methods of water treatment that are effective in eliminating bacterial forms. Consequently, it is essential that this phase of water bacteriology be thoroughly investigated: [1] to determine the quantitative relationship of virus pollution to coliform pollution of water; [2] to determine the relative rates of survival of both under natural conditions and with treatment; and [3] to develop methods for the quantitative detection and enumeration of viruses in water. Such studies have been undertaken by the Div. of Laboratories and Research of the New York State Dept. of Health, and it is hoped that some preliminary data will soon be available.

Until more information on the possibilities of survival of intestinal viruses in water and on the quantitative significance of streptococci is collected, it would seem essential to retain present standards and procedures based upon the density of the coliform group in a given sample of water.

Should Bacteriological Standards for Drinking Water Be Reevaluated?

By Max Levine

A portion of a paper presented on Oct. 30, 1952, at the California Section Meeting, Pasadena, Calif., by Max Levine, Chief, Bureau of Labs., Hawaii Dept. of Health, Honolulu, T.H.

IN the first edition (1905) of *Standard Methods* (*1*), as in the first studies on the Ohio River in 1914, the characteristics of organisms considered to be of sanitary significance were very carefully delineated. They had to be Gram-negative short rods, actively motile; reduce nitrates; produce indol; not form spores; and not liquefy gelatin. It required several weeks to determine all of these characteristics. Many coliform strains now accepted as significant were, therefore, excluded at that time.

The then standard methods of isolation, particularly with employment of the lactose bile presumptive test, were conducive to the loss of a very large proportion of coliform bacteria (as the term is now employed) and even a considerable proportion of the so-called typical *B. coli communis* (*Esch. coli*). At that time, the quantities of water tested were small—five 1-ml portions—and a supply was considered good if *B. coli communis* (*Esch. coli*) was absent from a majority of these 1-ml portions.

Improvements in methods of isolation ordinarily would be expected to result in relaxation of standards—that is, allowance of a somewhat greater incidence of *B. coli communis*, as that was the standard test organism—but the reverse has actually been true of water analysis in the United States. The concept of what constitutes an organism of sanitary significance (and, therefore, an index of pollution) was broadened by the simple procedure of redefining it to include all Gram-negative rods which ferment lactose with gas production, do not produce spores, and grow aerobically. Furthermore, 10 ml was adopted as the volume of the standard test portions for bacteriological examination, with not more than 20 per cent permitted (in 1914) to be positive for members of the coliform group. Later (1925), in consequence of the development and acceptance of chlorination, the tolerance for positive portions was decreased to 10 per cent.

Dual Nature of Standard

That such a rigid standard could be met is a compliment to the engineering practices developed for treatment and purification of water supplies. It should be borne in mind, however, that the coliform index, as now employed, thereby became something more than an index of safety: as applied to treated water supplies, it is

simultaneously an index of attainability.

Failure to give adequate recognition to this dual nature of the basis upon which, in the author's opinion, the present standard for drinking waters was evolved has led to confusion and legal complications, and may even result in chaotic conditions as attempts are made to apply this standard directly to other foods or beverages.

To illustrate the point of view being presented, it need merely be brought out that standards for mechanically operated swimming pools are generally the same as those for drinking waters (approximately one coliform per 100 ml) but, for bathing beaches, an index of 50 per 100 ml is considered very satisfactory—in fact, "Class A" —and even 1,000 per 100 ml is actually permitted. In West Virginia, for example, such a water is considered Class A for recreational purposes.

It is, therefore, not surprising that lay personnel, including members of the legal profession and even physicians and engineers, should be confused if asked to explain why a bathing beach is considered Class A if its water shows a coliform index of 50 or 100, whereas a swimming pool, with a much smaller index (say, 10) would be condemned. This confusion and apparent inconsistency disappears when the dual nature—safety and attainability—of the coliform index concept is recognized.

Consciously or unconsciously, this principle of attainability in setting standards based on the coliform index is actually being employed by regulatory officials. Thus, in the revised U.S. Public Health Service shellfish industry manual (*2*), the permissible coliform index was raised from an MPN of less than 230 to 2,400 when it was found that the lower index was economically inapplicable to soft-shell clams. The coliform index standard for oysters is far less rigid than that for water, and the recommendation to exclude the *Aerobacter* group from the index is further indication of recognition, perhaps unconscious, of the concept of attainability.

The fact that the present drinking-water standard was designed for waters which are, or can be, subjected to special treatments is all too often disregarded or not appreciated; and the tendency to project this rigid standard into the evaluation of the sanitary quality of frozen fruit juices, untreated waters, or even treated stored waters in tropical or subtropical localities is leading to much confusion and serious conflicts of opinion. Hawaii, for example, is confronted with the problem of high coliform indexes, due particularly to forms other than *Esch. coli,* in water supplies from protected watersheds.

Attempts to apply a single, inflexible coliform standard, designed for treated waters on interstate common carriers, to a number of very different local conditions leads to administrative difficulties. The indications are that reexamination of the basic concepts of sanitary indexes of pollution is warranted.

The English consider only the indol-positive strains of coliform bacteria as having sanitary significance, thus differing markedly from the American concept. This means that they disregard a very large proportion of the strains in the genus *Aerobacter,* many of the intermediates, and even a number of those which Americans would classify as *Escherichia.*

The Germans, through the use of the original Eijkman test, not only eliminate the entire genus *Aerobacter* but practically all strains of the intermediate (former *Citrobacter*) group as well. (Many of these grow but do not produce gas at 46°C and would, therefore, be missed.) Moreover, American experience indicates that many typical *Esch. coli* strains will not produce gas when examined by the original Eijkman test.

The question has been posed whether the present standards for drinking waters, and especially for nonchlorinated, but otherwise adequately protected or stored, water supplies and other beverages, should be reappraised and, if necessary, modified. In this connection, three lines of thought have been projected:

1. To supplement the present coliform index standard by incorporation of other possible indexes of pollution, such as tests for enterococci or even the various nonlactose-fermenting Gram-negative rods, among which are included some of the intestinal pathogens.

2. To relax the present standard by permitting a higher coliform index while employing the present coliform group.

3. To relax the present standard by incorporating recommendations for the differentiation of coliform types, some of which may be regarded as not being of sanitary significance.

Supplementary Tests

The coliform index was predicated on the assumption that typhoid fever, a disease peculiar to man, was the primary, if not the sole, waterborne disease of concern to this country; because of the difficulty and impracticability of isolating this specific pathogen, a count of the rather easily isolable coliform bacteria was adopted as a reasonable index or criterion of the probable relative incidence of typhoid organisms. Thus, the presence of coliform bacteria, in a stipulated volume of water, is considered an indication of danger and its absence a criterion of safety.

The universality of these criteria of hazard and safety has been questioned by qualified sanitary engineers and others. Such criticism is based primarily on reports in the literature indicating that gastroenteritis and even typhoid fever have been associated with water supplies presumably meeting the rigid USPHS standards and that many strains of Gram-negative nonlactose-fermenting bacteria pathogenic for man and particularly for young children (for example, some strains of the genera *Salmonella, Shigella, Proteus,* and *Pseudomonas*) might be present in waters even in the absence of coliform bacteria.

These deficiencies of the coliform index have brought forth suggestions for the establishment of supplemental tests, such as an "enterococcus index," or the utilization of newly developed techniques to detect specific enteric pathogens—dysentery (*Shigella*) and paratyphoid-like (*Salmonella*) organisms. Certainly, these possibilities should be explored.

Relaxation of Coliform Standards

Thanks to improvements in water quality, immunization, and sanitation, typhoid fever is disappearing. The case rate in Massachusetts fell from 64 per 100,000 population in 1914 to 0.73 in 1946—a drop of 98.6 per cent

(*3*). The incidence of typhoid fever cases and carriers contributing to stream pollution is consequently markedly decreased. Cox (*3*) noted that half of the typhoid carriers in New York State were over 60 years of age, so that an accelerated decrease in the contribution of typhoid bacilli is to be expected in the future. Consideration of these facts led to the suggestion (*3*), in Massachusetts (where some cities were experiencing difficulties in complying with the existing coliform standard), that, because the ratio of coliform to typhoid bacteria in polluted water is increasing, a higher coliform index could now be permitted in water while maintaining the same factor of safety which existed in 1925 when an index of one per 100 ml was adopted.

This is an interesting point of view on the relaxation of the present standard, but the problem is not really as simple as this approach would seem to indicate. It is suggested that, recognizing the principle of attainability, such a universal relaxation in standards would not be necessary, or desirable, for most water supplies. Furthermore, by incorporating the principles of attainability and differentiation of coliform types into the concept of the sanitary significance of coliform bacteria, a modification of present standards could be justified for special situations without falling back on the probably unwarranted assumption that the 1925 standard was really predicated upon safety, based on the ratio of typhoid to coliform bacteria in sewage; thus, universal relaxation in standards would be avoided, for only on their merits would special situations need to be considered for modification.

Coliform Differentiation

In view of English and German practice previously referred to, it is evident that many qualified scientists do not consider all coliform bacteria to be of the same sanitary significance. Fredericq and Levine (*4*) reported in 1947 that many coliform strains are markedly antibiotic against such intestinal bacterial pathogens as paratyphoid B (*Salmonella schottmuelleri*), *Salmonella enteritidis*, and many of the dysentery (*Shigella*) strains—enteric pathogens that are far more prevalent today than is typhoid fever. These *Salmonella* and *Shigella* strains, when inoculated heavily on agar plates upon which antibiotic coliform colonies had developed, did not grow within an area 30–60 mm in diameter around the coliform colonies, indicating that a very effective diffusible antibiotic was produced.

Recently Levine and Tanimoto (unpublished) have encountered coliform bacteria in Hawaii that are antibiotic against all of 23 available stock typhoid phage types, 44 of 45 *Salmonella* types, and 20 of 21 *Shigella* types tested, and also against the Arizona paracolon and coliform serotypes O–111 and O–55 reported responsible for infant diarrheas.

Surely coliform bacteria that are antibiotic against intestinal pathogens should not be looked upon with the same degree of suspicion and accorded the same sanitary significance as is attributed to strains that are inert or that may even stimulate the growth of enteric pathogens. The desirability and necessity for more intensive and discriminating studies of the various strains of coliform bacteria must be evident.

Need for Reevaluation and Research

Enough has probably been said to indicate that there is a need, not only for reevaluating the sanitary significance of the coliform group of bacteria, but also for a thorough search for other possible indexes that might either supplement or, in special instances, possibly replace the coliform index.

That confusion and difficulties have resulted from attempts to apply a single, inflexible coliform index standard to a variety of local conditions has already been indicated. The need for discretion in adoption, and exercise of judgment in application, of standards is evident.

The incidence of the coliform group is still the best and most reliable single sanitary index of pollution, but care must be taken, on the one hand, not to be so lulled into a false sense of security by the absence of coliform bacteria that studies on the possibility of finding and developing other indexes are neglected; and, on the other hand, not to continue to accord the same sanitary significance to a given coliform index for all localities and types of waters (or other beverages) irrespective of the nature of the coliform bacteria constituting that index.

Finally, it must be apparent that answers to the questions raised cannot be adequately supplied nor can present standards be markedly changed without considerable exploratory and basic fundamental research in the fields of intestinal, soil, and plant bacteriology. Among the types of studies that need to be prosecuted and that hold promise of yielding valuable information may be listed:

1. Development of selective media for isolation of members of the genus *Escherichia* from mixtures with other coliform bacteria

2. Utilization of the selective bacteriostatic properties of chemical compounds, antibiotics, bacteriophages, and other bacterial metabolites as tools for isolation and differentiation of fecal from plant varieties of coliform bacteria

3. Development of adequate techniques for detection, differentiation, and quantitative estimation of streptococci in sewage, water, and various foods

4. Differentiation, by biochemical properties and particularly by antigenic analysis, of coliform bacteria encountered in man or other animals from those growing in plants or present in soils not fertilized by animal manures

5. Antibiotic interrelationships among members of the genera *Escherichia, Aerobacter, Proteus, Salmonella, Eberthella, Shigella,* and *Erwinia*

6. Incidence and differentiation of types of coliform bacteria in feces of human beings at various ages and of different races.

7. Incidence and types of members of the genera *Proteus* and *Pseudomonas* in feces of man at various stages of his development.

Summary

Attempts to apply a single, inflexible coliform standard, which was originally designed for treated waters on interstate common carriers, to waters originating in, and subjected to, a number of very different local conditions with regard to treatment, storage, and temperature have led to administrative difficulties in some sections of the United States.

Although the objective of bacterial standards is safety, the problem of attainability is inherently a factor that determines what is considered an acceptable standard. This may be seen from a consideration and comparison of coliform index standards for swimming pools with those for bathing beaches, of standards for water with those for oysters and other foods, and so forth. Failure to recognize and appreciate this dual nature of bacterial standards—safety and attainability—is conducive to inflexibility in their application and renders difficult the problem of convincing legal authorities that the standards are rational and reasonable.

The need for more intensive and discriminatory studies of the coliform group of bacteria, with particular reference to their origin, viability in nature, and antigenic components, is stressed, and it is pointed out that many coliform bacteria are antibiotic against enteric bacterial pathogens. Attention is called to the possibilities of developing supplementary indexes, such as the incidence of enterococci, and the detection of specific pathogens. A list of suggested investigational studies that hold promise of yielding useful information upon which to base bacterial indexes of pollution is presented.

There should be constant alertness to the hazard of employing standards arbitrarily as a substitute for due appraisal of their applicability to situations under consideration. Standards should serve rather as reference points for discriminatory judgment.

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The Concentrometer Method of Applying Molecular Filter Membranes

By Alexander Goetz

A contribution to the Journal by Alexander Goetz, Assoc. Prof. of Physics and Project Director, California Institute of Technology, Pasadena, Calif.

THE customary use of molecular filter membranes for bacteriological water assays, about which a number of papers have been published (*1–7*) since 1951, has, in spite of many outstanding advantages, a few points in its disfavor in comparison with standard procedures. Although these disadvantages appear to have retarded the general acceptance of the molecular filter method, an analysis indicates that almost all of them result from the present manner of application rather than from the basic principle or the specific performance of the molecular filter material as such. These disadvantages are:

1. For untreated water samples of entirely unknown bacterial count, the volume of water to be filtered and the dilution rate cannot be predetermined, thus requiring the use of several separate filtrations in order to arrive at a bacterial concentration on the membrane that permits a reliable count (*4*). In view of the high price of the filter material, this has been considered to be a serious economic handicap, especially for mass tests.

2. High concentrations of coliform organisms, or of noncoliform organisms coexisting with small coliform organism populations may prevent satisfactory growth development (Endo sheen) and may result in uncertain information (*5–7*).

3. There prevails a general uncertainty on how to correlate the statistical values of the "most probable number" as defined in *Standard Methods* with the membrane filter count.

Briefly, the purpose of the innovation described in this paper is to meet all the above objections, and also, for reasons of economy, to crowd more significant information on a membrane area. The concentrometer method is designed, and has so far been able, to cut substantially the cost of the filter materials necessary for each test. On the other hand, the method does not require an alteration of the already developed techniques of nutrition and incubation or of the basic membrane materials available at present; the membranes differ only in shape and assembly from those in use at present. The procedure consists of a new physical application of the molecular filter membrane to the isolation of suspended matter and bacteria from water samples.

Concentrometer Principle

The basic purpose of the concentrometer is the production of a cuneal (wedge-shaped) deposit on the filter that does not require a graded porosity

membrane or support. The principle of operation may be illustrated by a simple example: Assume a rectangular tank, containing the water sample volume *abx* (Fig. 1), one side of the tank being a rigid, but porous, wall supporting a rectangular membrane (MF) and all the other walls being impermeable. If a vacuum can be applied to the porous wall (or a positive pressure to the tank), the water contained in the tank will be forced, and thus filtered, through the membrane, and a deposit of the matter suspended in the water will be formed on the inside of the membrane. Contrary to normal filtration procedures, this deposit will not form a uniform layer but a wedge, because the volume of the liquid forced through each horizontal section of the membrane will depend upon the level of the liquid within the tank, which, as it is gradually lowered, passes a decreasing fraction of the filter area. As the deposit is proportional to the volume that has passed through each horizontal section of the membrane, the deposit will be denser in the lower than in the upper part, but it will be uniform within each horizontal section.

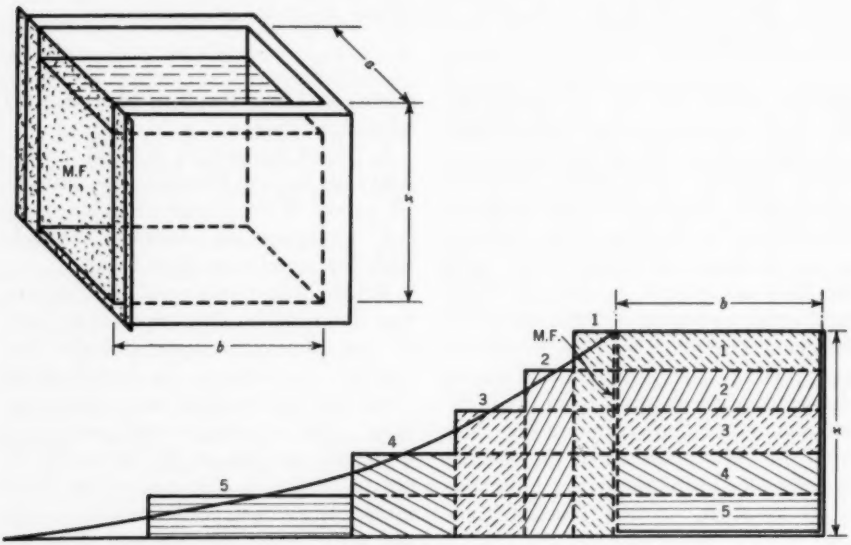

Fig. 1. Schematic Illustration of Concentrometer Principle

Top: rectangular tank with molecular filter membrane (MF) wall (width b, *height* x, *depth,* a). *Bottom: schematic vertical cross section of tank. To the right of MF, the sample volume is divided in five equal layers; to the left of MF the flow passing each section is shown, with corresponding volumes in identical hatching. The curve shows the actual flow distribution. The area under the steps and that under the curve equal the tank area.*

This action is schematically illustrated in Fig. 1 (bottom), which shows a vertical cross section of the tank with the MF wall as its left border. If the membrane is regarded as being divided into five horizontal sections,

the average quantities that pass through each section are represented by the abscissa of the step curve at left. When the water level in the tank has dropped from the top to the bottom of Section 1, one-fifth of this volume has passed through that section, because every other section passes the same quantity simultaneously. Thereafter no more water can pass through Section 1. Similarly, one-fourth of the remaining volume of water in the tank is filtered through Section 2 (in addition to the one-fifth of the total volume previously passed), and so on until Section 5 (the lowest section) has to filter all the water left in the tank, in addition to the quantity that has already passed through. In reality, the process is continuous, so that, in Fig. 1, the line curve rather than the step curve represents the flow through each section and thus the deposit density—that is, the profile of the wedge formed by retained particles.

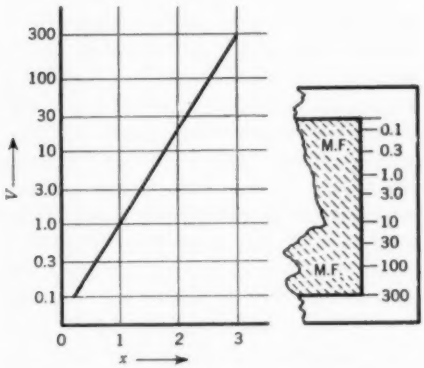

Fig. 2. Exponential Flow Function

Left: exponential flow function (volume, V, versus height, x) of molecular filter, corresponding to serial-dilution (MPN) technique. Right: corresponding flow scale on filter frame.

It is apparent that this type of filtration through a vertical filter is possible only if the pores of the filter remain impermeable to air when they are no longer submerged in the liquid. Otherwise, it would be impossible to maintain a pressure differential across the porous wall and facilitate filtration when the liquid level does not cover the wall completely. This condition is uniquely fulfilled for liquids with the surface tension of water when the pore sizes in molecular filter membranes are those required for the quantitative retention of bacteria. The membrane is impermeable to air at pressures up to 3 atmospheres or more when the pores are filled with water. Consequently, the pressure differential remains un-

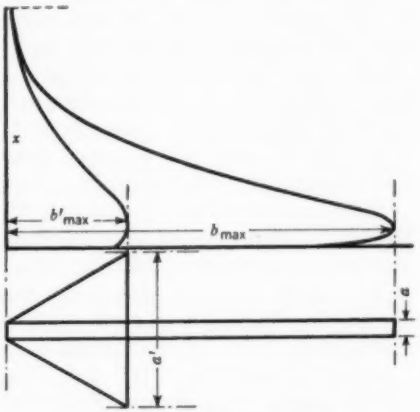

Fig. 3. Profile of Container

Top: vertical cross section showing tank profile resulting in exponential flow distribution through height, x, of filter. Maximal length of container, b, corresponds to tank depth, a. Bottom: horizontal cross section for rectangular (a) and trapezoidal (a') shape; the latter reduces b_{max} *to* b'_{max}. *The area of the rectangle equals that of the trapezoid. (Vertical scale, x, is exaggerated.)*

changed when part of a wet membrane is in contact with air on both sides.

In order to utilize this principle in bacteriological and suspended-solids determinations in water, however, the range between minimal and maximal volumes passing the membrane on the upper and lower edge has to be very much larger than is possible with a rectangular tank of any dimensions. Another requirement is that the shape of the cuneal deposit should derive from the mathematical function upon which the MPN determination is based—that is, an exponential function in which each decade of volume (0.1, 1, 10, 100 ml, etc.) fills an equal fraction of the filter area (Fig. 2).

This condition can be fulfilled, although it requires somewhat involved mathematical considerations that result in a tank of prismatic shape, the top of which follows a curved surface shown as a vertical cross section on a condensed scale in Fig. 3. This curved surface determines the exact volume available to each horizontal section of the membrane, following the exponential flow condition shown in Fig. 2.

In order to reach into the concentration ranges required in sanitary water bacteriology (1:10,000 or greater), impracticable dimensions result for b_{max} (Fig. 3), the largest distance between the membrane and the opposite wall of the lower part of the container. For instance, for the flow function in Fig. 2, with a total sample capacity of 300 ml and $a = 1\frac{3}{8}$ in., b_{max} would approach 3 ft.

This difficulty can successfully be avoided by giving the tank a horizontal cross section in the shape of a trapezoid (Fig. 3) with 60-deg base angles. The container volume then increases with the distance of the curved surface from the filter membrane and b_{max} is reduced to practical dimensions (b'_{max}), as shown in Fig. 3 in analogous proportion.

Description of Concentrometer

The mathematical theory now developed for this type of filtration permits the adaptation of the principle to almost any concentration range and sensitivity. For the particular instrument described, the specifications are determined by several factors.

Bacterial concentrations, particularly in sanitary water tests, range from those tolerated in drinking-water standards (approximately 1 coliform organism per 100 ml) to 50,000 per 100 ml for raw water to be treated by chlorination (*8*). The former determines the choice of the total water sample, which must be sufficiently large to decide, within the margin of statistical error, whether or not more than 1 organism per 100 ml is present. A factor of three being considered to provide adequate reliability, the total volume of the concentrometer has been standardized to 300 ml of sample.

The minimal volume to be discernible on the molecular filter has been chosen as 0.1 ml. Other mathematical considerations with regard to reliability, analogy to MPN methods, and economy of filter surface have resulted in the choice of a membrane area 3 cm high (x) and 4 cm wide (a). These data are sufficient for designing the dimensions of the instrument.

A number of additional features necessary for foolproof, practical manipulation may be listed in the order of their importance:

1. A convenient and accurate way of introducing the required amount of sample into the tank must be provided.

2. The bottom of the tank must be such that no water residue is left by adhesion due to imperfect wetting, as the water surface must remain a perfect plane at any time during and at the termination of filtration.

3. The molecular filter membrane must be held during filtration in a position in which the x scale is reliably correlated with respect to the curvature of the container.

4. All surfaces which come in contact with sample water must be sterilizable.

These conditions are relatively simple to meet by the construction shown in Fig. 4. The vertical cross section through the axis of symmetry shows the container, T, to be a prismatic, sealed unit with plane sides and a curved top surface. The top view (above) shows the trapezoidal shape. Permanently attached to T is a face plate with a rectangular aperture through which the interior of T is accessible.

The bottom of T is supported by a star-shaped brace construction, B, to prevent warping. Attached to T are the bubble levels, N_1 and N_2. The whole assembly is supported by a massive tripod, S, with two leveling screws, so that T can easily be lifted from S if the interior is to be cleaned.

Hinged to the face plate of T is the filter holder assembly, F (Fig. 4, upper right). The upper half of F serves as support for the filter, providing a shallow recess for its frame; a rectangular, porous carbon plate, P, backs the membrane proper. The lower part of F contains a two-way cock, C, which either connects the vacuum space behind P with the outlet O_2, or else connects a slitlike drain, D, corresponding to the bottom of T, with the outlet O_1. A thin, permanently attached gasket provides a seal between the faces of F and T when they are pressed together by a simple locking device.

The face plates of F and T are shaped so that the upper left corner of the filter frame is accessible, to render the use of a forceps unnecessary. F can be separated from T by removal of pin G.

This design was given preference over numerous alternative constructions because of simplicity of operation. In operation, hose nipples, O_1 and O_2, are connected (Fig. 4) to a sample container (or funnel) and a flask (500–1,000 ml), respectively, the latter being connected to a hand- or motor-driven vacuum pump or aspirator.

After leveling the tank, the filter is inserted into F; the latter is then locked to T; and the cock, C, is put into horizontal position. The sample container is lifted so that its contents flow through D into T, filling the latter, while the displaced air escapes through a slit formed by the upper edge of the curved surface. The water, when it has reached the upper level, U, spills over this edge. The spilled quantity remains above the curved surface and is drained through the rear ridge. Upon the first spilling, C is turned into vertical position, which starts filtration instantaneously. The sample container is then lowered into a suitable support, so that the remaining water level in it is below the bottom of the tank.

Filtration is completed in 3–5 min, either when the water has reached the lower level, L, or, if premature clogging occurs, when there is no further outflow into the flask. The time required is almost the same whether or not clogging occurs. Then C is turned into the first position and T drains back into the sample container. F is

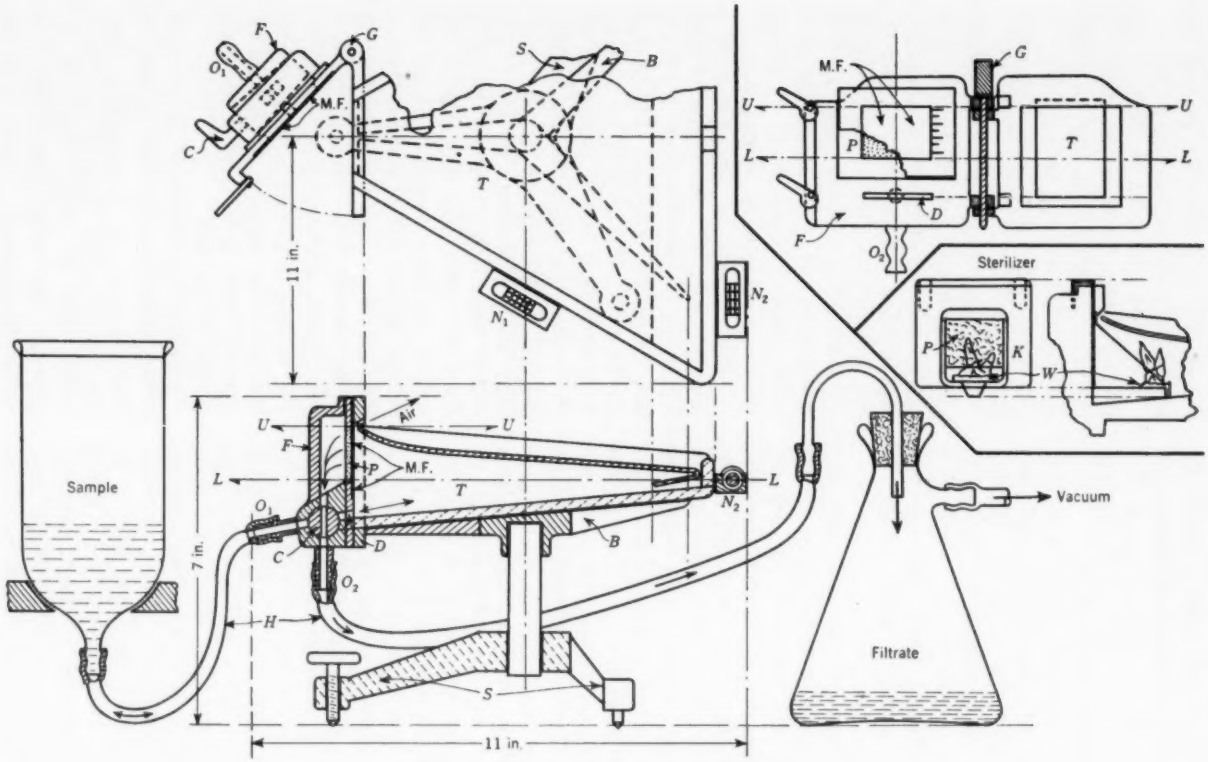

Fig. 4. Construction of Concentrometer

Left: top view and vertical cross section of concentrometer. Upper right: frontal view of filter holder, F, *hinged to face-plate of container,* T. *Middle right: methanol burner attached to* F *and inserted into* T *for sterilization of cavity walls.*

then unlocked, and the filter frame removed and transferred to a nutrient pad. The instrument is now ready for a new sample, unless prior sterilization is required. For serial tests on similar water samples, sterilization will usually be unnecessary.

Sterilization of equipment will chiefly concern the tank cavity, *T*, and only occasionally also the interior of *F*. For the sterilization of the tank cavity, the method developed previously (*4*) for the standard molecular filter equipment has been adapted to the concentrometer. A metal plate, *K* (Fig. 4, right), of a size and shape to fit into the membrane filter recess and to hook over the top of *S*, carries an asbestos wick, *W*, on a small horizontal platform. After *K* is hung over *F*, 1–2 ml methanol (CH_3OH) is dropped on *W;* the latter is lit and *F* is shut against *T*. The rapidly reducing oxygen content in the *T* cavity causes the flame almost immediately to develop for a few seconds a substantial quantity of formaldehyde (HCOH) before it goes out. The formaldehyde produced is sufficient for rapid disinfection of the whole interior, including the porous backing, *P*, which the shape of *K* leaves fully exposed.

The sterilization of *F* as a whole can be performed in an autoclave after separation from *T* by the removal of *G*.

Filling of the tank from below assures (owing to overflow) accurate volume, avoids interfering factors such as air bubbles, and does not require a volume determination by the operator. To obtain proper scale correlation, the membrane is supplied mounted in a frame of stiff paper the inner dimensions of which exactly equal those of the filter. The frame carries an imprint of one (or several) scales (as in Fig. 2, right) or even a red warning mark indicating the drinking-water standard. The one factor left to the skill of the operator is the fairly accurate leveling of the instrument. Any substantial deviation of the water level from the instrument horizontal (*U–U* in Fig. 4) alters the relationship between scale and flow.

The actual dimensions of an instrument meeting the conditions described are approximately as shown in Table 1.

TABLE 1

Concentrometer Dimensions

Item	Dimension
Overall height	7 in.
Width	4–11 in.
Length	11 in.
Total water capacity	700 ml
Total sample capacity	300 ml
MF frame	$2\frac{1}{2} \times 2$ in.
MF area	3×4 cm

The tank assembly, *T*, is at present made from translucent plastic, which can, with relatively little difficulty, be molded into the required shape. The filter holder, *F*, is made from corrosion-proof metal.

Flow and Deposit Characteristics

One unusual, though probably obvious, quality of the concentrometer is contrary to standard filtration procedure, even for a completely particle-free (nonclogging) sample: the flow rate declines rapidly because the membrane area available for filtration decreases steadily with the lowering of the water level in the container. In the presence of suspended matter, this decline is more rapid, but the flow rate never alters in any way the distribution of particles retained on the filter because the volume available for

passing a given horizontal section of the membrane is determined only by the horizontal cavity area at this point and not by the flow. If the filter begins to clog gradually, the entire area below the water level has, at any instant, retained an equal amount and suffered the same reduction of flow, and the water level in the container is lowered more slowly in proportion. From this it follows that the cuneal deposit of bacteria on the filter is not influenced by retained neutral suspended matter, even if the latter finally clogs the filter before the entire sample has passed through. In this situation, the unused portion of the sample is drained through the cock, *C*, without interfering with the deposit prior to clogging—in contrast to the present method of the "fixed" sample, in which the excess water above the clogged membrane has to be poured out, thereby disturbing the bacterial deposit on it. If, for instance, the filter clogs after 100 ml has passed through, the residual 200 ml is drained. The scale remains valid up to 100 ml, permitting a count as low as 1 organism per 100 ml.

When a low bacterial count coincides with a high degree of suspended matter, the question arises whether the absence of colonies is misleading because clogging occurred before a sufficient sample volume passed the filter or because the suspended matter retained on it interfered in some way with the typical growth habits (imbedding, for example) of the bacteria.

The concentrometer allows for a fairly accurate estimate of the "limit of detection" of organisms for most concentrations and types of suspended matter. As previously noted, each horizontal membrane "strip" filters a different fraction of the sample volume. Clogging will occur, if at all, at and below that strip where the amount of matter retained seals the pores completely. This strip is, in general, easily visible and can be located within a width of approximately 1 mm. Above the strip the membrane is permeable because less water has passed through it. Below is an area through each unit of which the same amount has passed as through the clogged strip.

Obviously, the "limit of detection" concerns the sample volume which has passed *above* the clogged strip. If the latter lies, say, between 30 and 100 ml on the scale and no colony develops, the interpretation must be that the bacterial count is less than 3 per 100 ml. In other words, reliable information would be limited to a maximal sample volume of approximately 30 ml. This interpretation is not entirely accurate, as a larger total quantity of the sample may have passed the clogged area and the bacteria deposited may grow in spite of the clogged condition. (Discussion of this possibility is omitted as being of little practical value.)

The main advantage of the concentrometer over the customary method of the "fixed" sample is that some fraction of the filter area will remain unclogged and thus capable of supporting normal growth.

Interpretation of Results

Although the interpretation of the counts on the concentrometer membrane may be evident from the preceding analysis, it appears useful to discuss a specific illustration in detail. Assuming that a water sample contains an average coliform concentration of 60 organisms per 100 ml, 300 ml of this sample will pass through the concentrometer and will produce on the membrane, after nutrition and

incubation on a differentiating nutrient schedule (*4, 6, 7*), the pattern (constructed from calculation) shown in Fig. 5.

In the absence of major statistical fluctuations, such as "skips," there should be two colonies above the 3-ml mark on the filter frame scale. It should be understood that the position of the colonies in this section of the filter membrane is entirely accidental and that, owing to statistical fluctuations, more or fewer such colonies may appear. In fact, the occurrence of colonies above a particular mark on the scale is controlled by the same statistical laws as the occurrence of gas in a normal lactose broth test, the sample portion being equivalent to the quantity of sample indicated on the x scale.

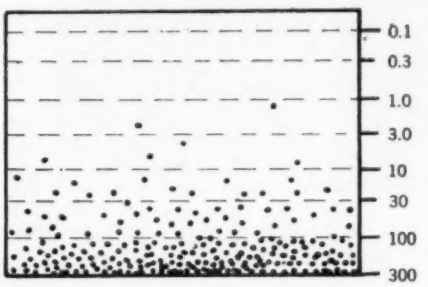

Fig. 5. Distribution of Bacterial Colonies
The drawing shows the theoretical distribution of bacterial colonies (60 organisms per 100 ml) on the concentrometer.

If the line is lowered to the 10-ml division, six colonies should appear above it; above the 30-ml division, 20 colonies; and so on. The most convenient procedure is to find a dividing line above which lies a reliably countable number of colonies, such as 10–30, and to read the corresponding scale divisions (in Fig. 5, 30 ml with 20 colonies). The count, if smaller (larger) than 15, can then be compared with one taken at the next lower (higher) division—for instance, 6 at 10 ml—if it is desirable to check the result for reliability.

Interpretation is particularly simple for treated water supplies. The sample passes the sanitary water requirement for drinking water when only one coliform colony appears above the 100-ml mark and not more than three colonies in the entire filter field.

The upper reliable limit of the instrument depends on the following considerations. If it is assumed conservatively that the limit of countability of coliform colonies is 32 per square centimeter (although much higher colony densities have been obtained under favorable conditions), above the 0.1 ml mark 25–26 colonies are reliably discernible, for which 80 sq mm of filter area (2 mm × 40 mm) are available. This figure establishes as the upper reliable limit a concentration of at least 25,000 organisms per 100 ml. The instrument thus has a range of 1 to 75,000 organisms per 300 ml.

Using a fixed sample volume and assuming a maximal reliable density of approximately 32 colonies per square centimeter, one standard filter (47-mm diameter, 9.6-sq cm effective filtering area) can produce not more than 300 organisms with characteristic growth habits. The filtration of a 300-ml sample will thus yield accurate information on 1–300 organisms per 300 ml. If the next step is 100 ml of a 1:100 dilution of the sample, the second filter will cover from 3×10^2 to 9×10^4 organisms per 300 ml. In actual practice, sufficiently overlapping counts are necessary, requiring at least 3 filters (60-sq cm total area) for a 300-ml undiluted sample, a 10-ml undiluted sample, and a 30-ml 1:100 di-

luted sample, covering 100-ml count ranges of 0.3–100, 10–3,000, and 300–90,000 organisms, respectively. The advantages of the concentrometer are obviously an economy of filter material and less need for manipulation (no dilution and metering operation); moreover, counting more than 20–40 colonies is not required.

In comparing the concentrometer with the MPN determination resulting from a division of the sample into a number of individual portions, attention must be given to both range and reliability of information. The MPN determination over approximately the same range and involving approximately the same sample volume (314 ml) as the concentrometer of the above dimensions requires (*9*) a division of the sample about as follows: two 100-ml, two 50-ml, and one 10-ml portion to cover the range 0.3–5 organisms per 100 ml; three 1-ml and three 0.1-ml portions to enlarge the range to 460–1,100 organisms per 100 ml; and three 0.01-ml and three 0.001-ml portions to enlarge the range to that of the concentrometer.

With regard to the reliability of information, the 300-ml sample is divided into eight different portions at approximately equal logarithmic intervals—namely, 300, 100, 30, 10, 3, 1, 0.3, and 0.1. In other words, if one or more colonies lie above, say, the 10-ml mark, this is equivalent to gas in one 10-ml portion. If, however, one or more of these colonies lie above the 3-ml mark, this would correspond to gas in one to three 3-ml portions or one to ten 1-ml portions and so forth. As, in each horizontal section, 20–50 colonies can be cultured, the reliability of the count above a particular volume division on the membrane filter scale is comparable to the MPN derived from a subdivision of the sample volume, V, into approximately 20 portions, each representing $0.05V$. (The number 20 is, however, somewhat arbitrary, because many factors aside from colony density on the molecular filter membrane influence the magnitude of the statistical fluctuation, which determines the relative position of each colony on the membrane.) The reliability of the con-

TABLE 2

Typical Laboratory Results

x Scale *ml*	Total Count						Coliform Count (Sheen)					
	I		II		III		I		II		III	
0.1	0	(0)	2	(1−)	*9*	(*5*)	0	(0)	0	(0)	0	(0)
0.3	1	(0)	3	(1–2)	*22*	(*17*)	0	(0)	0	(0)	1	(1−)
1.0	*3*	(0)	7	(5)	76	(50)	0	(0)	0	(0)	4	(2)
3.0	5	(1–2)	*22*	(*17*)	160+	(167)	0	(0)	0	(1–2)	*14*	(*7*)
10.0	7	(5)	*45*	(*50*)	TMTC*	(500)	0	(0)	1	(2)	*22*	(*20*)
30.0	*11*	(*16*)	86	(167)	TMTC*	(1,670)	0	(1−)	*4*	(*7*)	39	(67)
100.0	*52*	(*50*)	280+	(500)	TMTC*	(5,000)	2	(2)	*10*	(*20*)	39	(200)
300.0	80+	(150)	TMTC*	(1,500)	TMTC*	(15,000)	10	(6)		(60)	39	(600)

* Too many to count.

centrometer is thus much greater than is needed for most practical problems in the field of water sanitation. Hence, the use of only two or three parallel sample portions (instead of 20) will be sufficiently accurate and may be used as a basis for a comparison of the glassware and labor requirements by the concentrometer and MPN determinations.

For the MPN test, the water has to be divided into 20 portions involving three serial dilution steps. These require at least 43 sterile glass tubes and flasks, four pipets, one graduate, and approximately 350 ml of lactose broth, excluding the water sample bottle. The concentrometer requires no sterile glassware and if, instead of dehydrated nutrient schedules, laboratory-prepared nutrient media are to be used for each test, not more than 5 ml is necessary.

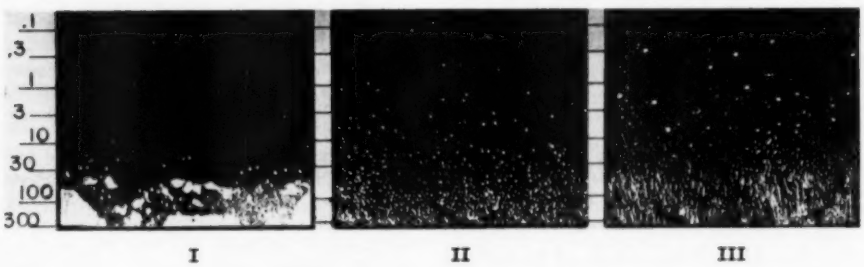

Fig. 6. Typical Laboratory Results

The numerals I, II, and III below the concentrometer membranes correspond to a 1:10:100 serial dilution of a water sample containing Serratia marcescens *and* Esch. coli *in a ratio of approximately 25:1. The membranes were incubated for 16 hr at 37°C.*

Typical Laboratory Results

The concentrometric method of bacteriological analysis of water represents a radical departure from customary techniques and will require detailed evaluation for many specific uses. Actual performance may be demonstrated by the typical data in Table 2 and the photographs shown in Fig. 6. Concentrometric filtration was performed on a water sample bearing *Serratia marcescens* and *Esch. coli* (25:1). The sample was diluted in three steps, so that Sample I carried one-tenth the concentration of Sample II and one-hundredth that of Sample III. A concentrometer test was run on each of these samples. The molecular filter membranes were subsequently incubated (*4*) for 16 hr on a dehydrated Endo nutrient schedule (Isopor). Counts of sheen- and non-sheen-bearing colonies were taken. Table 2 gives both counts for each scale division. Shown in parentheses is the number to be expected, provided the average is correct and the dilution ratio was exactly as planned.

The data indicate good agreement between the actual and expected counts, within the margin of statistical uncertainty, up to 50–80. Beyond this

point, the counts are increasingly less than they should be. It is also evident that excessive densities of *Serratia marcescens* (Sample III) suppress either the growth of *Esch. coli* or the sheen development. Hence Sample III has sheen colonies only in the scale range 0.1–10 ml and not for larger quantities.

The italicized values in the table indicate those counts which, according to the preceding discussion, should have been taken in order to establish the concentration reliably. Similar tests on untreated and treated sewage effluents have produced analogous results.

Acknowledgment

The author is greatly indebted to J. E. McKee, Assoc. Prof. of San. Eng., California Institute of Technology, Pasadena, Calif., for specific advice and many valuable criticisms; to Noel Tsuneishi, Chief Bacteriologist, AG Chemical Co., Pasadena, Calif.; and to L. R. Burt for building the first instruments.

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Emergency Meter Specifications Rescinded

As a result of improved materials supply, particularly in nonferrous metals, and the relaxation of official controls, the "Emergency Alternate Provisions" to meter specifications AWWA C700, C701, C702, C703, and C704 have been rescinded, effective Aug. 17, 1953. The change will have little practical effect upon meter manufacture, as for some time now the producers generally have not found it necessary to make the substitutions authorized by the emergency alternate provisions.

Users of the meter standards may bring their copies of the specifications up to date simply by removing the blue covers, on which the emergency provisions were printed.

New Medium for Bacteriological Analysis With Molecular Filter Membranes

By George S. Yee, Wilfred B. Krabek, and Charles P. Schaufus

A contribution to the Journal by George S. Yee, Wilfred B. Krabek, and Charles P. Schaufus, all of Lovell Chemical Co., Watertown, Mass.

THE development of the molecular filter membrane has made possible a new and more rapid method of isolation and identification of bacterial organisms. Bacteria are filtered from a hydrosol and cultured on the surface of the filter by means of a liquid nutrient. In this way, larger samples can be tested, thus assuring more accurate determinations. Results can be obtained in a much shorter time. This paper is concerned with a new medium that can be used in the bacteriological examination of water for coliform organisms.

This study employed the American-made membrane filter * resulting from the investigations of Alexander Goetz (*1, 2*) of the California Institute of Technology, Pasadena, Calif. For the analysis of water, hydrosol assay disks with an imprinted grid marking were used.

Reported Methods

The Environmental Health Center of the U.S. Public Health Service for several years has been investigating the application of the membrane filter to the bacteriological examination of water. Clark and others (*3*) report a modification of Endo's medium for use in a quantitative estimation of the coliform organisms in water. They state that the test procedure should enumerate all coliform organisms present in the sample, be specific for members of the coliform group, and be simple and rapid.

Goetz and Tsuneishi (*1*) report the use of a Gassner type of medium containing a yellow dye (Fast Mordant Yellow) that partially inhibits cocci and spore formers but does not affect the development of *Salmonella* and coliform organisms. This method required special treatment of the filters and was therefore abandoned. Clark and Kabler (*4*) report a method for the isolation of the coliform group using a modification of the Endo's medium in a two-stage procedure. The first stage calls for an enrichment period allowing all the bacteria to grow, and the second stage uses a medium containing the inhibitory dye, basic fuchsin. This medium depends on the production of a metallic sheen by organisms fermenting lactose contained in the broth. Later reports indicate that coliform organisms were inhibited by the presence of a large number of noncoliform bacteria, especially in a sample containing relatively few coliform organisms. Thus, a modification

* Manufactured by Lovell Chemical Co., Watertown, Mass., under the registered trade name, "Millipore Filter MF."

of the methods described by Clark and Kabler (*4*) which would inhibit the noncoliform bacteria without affecting the coliform bacteria was necessary.

Methods using different concentrations of basic fuchsin dye with varying concentrations of basal mediums were tried unsuccessfully and were therefore abandoned. The use of chemicals that would inhibit the noncoliform bacteria without impairing the growth of coliform bacteria was adopted as an approach to the problem. The most successful of the materials tried was 8-hydroxyquinoline, which was incorporated in the medium. This chemical, more commonly known as oxine, is a mildly cationic agent that, according to unpublished data, exerts a more effective inhibition on Gram-positive than on Gram-negative organisms.

A study was initiated to compare the effects of an Endo medium with and without oxine and to compare the present standard method for the determination of coliform bacteria (*5*) with the membrane filter method.

The methods for the membrane filter procedure are based on those of Clark and others (*3*) with the exception of two changes. In using Neopeptone * in the basal medium, a precipitate was formed. Albimi M peptone † at the same concentration as the Neopeptone eliminated the precipitate and was therefore adopted. Second, plastic petri dishes developed by the authors' firm were used in incubation in place of 60-mm glass petri dishes. The condition of humidification, which is an important factor in the membrane filter method, was felt to be more uniform within the plastic dish, moisture vapor being supplied by the liquid medium itself rather than being controlled either by incubation in a water bath or by humidifying the incubator.

* A product of Difco Labs., Inc., Detroit.
† A product of Albimi Labs., Inc., New York.

Preparation of Media

The media were in broth form and all reagents used were chemically pure or reagent grade. The formulations were:

Enrichment Medium

Peptone M (Albimi)	40 g
Yeast autolysate (Albimi) ..	6 g
Sodium chloride	2.5 g
Lactose	5 g
Distilled water	1,000 ml

Adjust to pH 7.0 with KOH solution. Sterilize at 121°C for 15 min.

Basal Medium

Peptone M	20 g
Lactose	20 g
Distilled water	1,000 ml

Adjust to pH 7.5 with KOH solution. Sterilize at 121°C for 15 min.

Oxine (8-hydroxyquinoline)

A 1:10 dilution of a standard aqueous stock solution containing approximately 1 g of oxine in 1,000 ml of distilled water. This stock solution may be stored indefinitely.

Dye Solutions

a. 9 per cent sodium sulfite solution (aqueous)
b. 3 per cent basic fuchsin

The basic fuchsin is dissolved in one part of 95 per cent alcohol, thoroughly mixed, and then diluted with an equal part of distilled water.

Dye solutions should be prepared each day.

Standardization of Fuchsin Dye

The standardization of a lot of fuchsin dye is a critical procedure and should be done carefully. Essentially, the pro-

cedure consists of incubating coliform organisms on a medium containing varying amounts of fuchsin with a fixed amount of sodium sulfite. The ratio of fuchsin to sulfite permitting the recovery of the largest number of coliform organisms is chosen as long as that dye lot is available. The fuchsin concentration should be sufficient to develop proper sheen but should not interfere with the growth of the coliform bacteria. It is suggested that, instead of using a known culture in the titration, either diluted sewage or raw water be employed.

Fig. 1. Membrane Filter Holder

A pyrex glass filter holder was used in this study on the membrane filter.

The medium developed at the authors' laboratory, designated "LCC broth," is prepared in the following manner: To each 30 ml of the basal medium 8 ml of oxine solution is added. To this solution is added an amount of the fuchsin-sulfite solution (on the order of 1–2 ml) as determined by the fuchsin standardization.

Technique Employed

The technique used in this comparison consists of the filtration of a known amount of water sample through a membrane filter retained in a pyrex glass filter unit (Fig. 1). After filtration has been completed, the membranes are transferred to plastic petri dishes containing absorbent pads saturated with 1.7 ml of enrichment broth. These are then placed in an incubator at 37°C, in an inverted position, for a period of 2–3 hr. After the enrichment period the membranes are transferred to plastic petri dishes containing absorbent pads saturated with 1.7 ml of the LCC medium. These dishes are then replaced in the incubator in an inverted position, allowing adequate spacing for the free circulation of air between them, and are incubated for a period of 14–20 hr at 37°C. After removal from the incubator, the filters are placed on an absorbent paper and allowed to dry. Colonies showing a metallic sheen are considered coliform organisms (*6*).

The most practical procedure to select for comparison with the membrane filter technique is the "Most Probable Number" determination of coliform organisms in water, described in *Standard Methods* (*5*). This method consists essentially of planting varying amounts of the water to be tested in lactose broth and observing the formation of gas (presumptive test). The presence of the coliform group in the tubes producing gas is confirmed by subculturing in BGB

lactose broth or in solid differential media (EMB agar or Endo agar), with subsequent identification of the coliform organisms.

TABLE 1

Comparison of MPN and Membrane Filter Results

Test No.	Total Count	MPN*	LCC*
Reservoirs			
1	9,370	89	84
2	4,880	29	29
3	2,400	66	71
4	84	3.5	13.4
5	458	1.05	2.0
Wells			
1	443	0.2	1.3
2	6.3	0	0
3	121	0	0.05
4	882	0	12.4
5	1,860	0	0.4
6	1,663	2.6	8
Finished Water			
1	349	0.18	0.28
2	251	0	0.54
3	75	0	0.06
4	1,286	0	4.7
5	135	0	0
Rivers			
1	112,300	9,890	9,810
2	15,000	13.9	44
3	11,000	826	721
4	7,400	887	1,770
5	3,580	1	4

* Per 100 ml.

Ten MPN analyses were prepared for each water source, five tubes being used for each dilution and three or more dilutions run for each sample. The positive tubes were confirmed on EMB agar after 24 and 48 hr. Various sources of water were tested, including: surface waters, such as ponds and reservoirs; wells, both deep and shallow; finished waters for normal consumption; and rivers, especially those used as a source of public supplies.

Results

The results of these analyses were compared with ten membrane filter determinations made as described earlier in this paper. The data are presented in Table 1, in terms of counts per 100 ml of water sample. The sample volumes used in the membrane filter method varied from 1 to 500 ml, while those used in the MPN method remained constant at 56 ml for each MPN determination. Total counts are included in the table to give an indication of the bacterial density of the water samples tested. These counts were obtained by culturing the bacteria collected on the surface of the membrane filter, employing an 18-hr incubation period on the enrichment medium alone.

Samples were chosen from water sources that are routinely tested for pollution. Thus, samples of finished or deep well waters containing no coliform organisms would show little or no index of pollution. In several samples tested, coliform organisms were detected with the membrane filter using the LCC medium although not with the MPN determination. This discrepancy may be due, in part at least, to the use of larger volumes of water with the membrane filter.

Background Organisms

When large amounts of water are added to broth, the possibility of an-

tagonistic action of organisms must be considered (*7*). In the membrane filter method, this possibility is greatly decreased, owing to the minimal lateral diffusion across the surface of the membrane. The effect appears, if at all, only when the number of colonies on the filter is extremely large.

It will be observed that the coliform densities indicated by the membrane filter method using the LCC modification of the Endo medium compares favorably with the MPN results. The LCC medium gave generally higher counts in all the types of water sampled than the MPN procedure did.

Of the colonies transferred to lactose broth gas tubes, approximately 81 per cent of the sheen colonies and 22 per cent of the nonsheen colonies produced gas. These results were obtained from colonies observed for sheen in the wet state. When colonies are allowed to dry out, sheen sometimes appears on some of the colonies not previously showing it in the hydrated stage. When this effect is considered, the number of false negatives decreases and thus the positive gas confirmation will increase.

When a large number of bacteria is present on the filter membrane, either because of the high bacterial density or because of the use of large volumes of water, a heavy "background" of noncoliform colonies frequently occurs. When excessive, this background apparently interferes with the proper formation of the metallic sheen characterizing the coliform organisms. Media were prepared both with and without oxine. As indicated in Fig. 2 and 3 and in Table 2, there appears to be a definite tendency toward inhibition of the noncoliform background by the oxine formulation, resulting in a smaller background count of bacteria.

Fig. 2. Effect of Oxine

The low background count shows the effect of oxine in the medium.

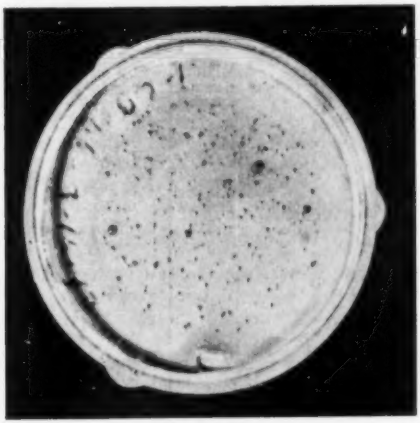

Fig. 3. Absence of Oxine

The sample used was of the same size and from the same water source as in Fig. 2.

The filters in Fig. 2 and 3 were used in testing equal samples taken from the same water source. Both show the same coliform count. The background is greatly decreased in the presence of oxine (Fig. 2, count 48) as compared with the background in the absence of oxine (Fig. 3, count 418).

Table 2 provides a comparison of the background counts using the two media. The figures in columns 2 (without oxine) and 3 (with oxine) were obtained by counting all the colonies developed on the filter and subtracting the number of coliform colonies, the result being the background count of the noncoliform bacteria on the filter. The table indicates that a decrease of approximately 25–50 per cent in the noncoliform colonies occurs when oxine is added to the medium.

TABLE 2

Comparison of Background Counts on Differential Coliform Media With and Without Oxine

1	2	3	4	5
Water Source*	Without Oxine	With Oxine	$\frac{\text{Col. 3}}{\text{Col. 2}}$	Decrease *per cent*
Reservoirs				
1	250	248	0.99	1
2	69	50	0.73	27
4	212	159	0.75	25
5	159	111	0.70	30
Avg				21
Wells				
1	113	72	0.64	36
2	2	1	0.50	50
3	58	48	0.83	17
4	18	8	0.48	52
5	11	9	0.82	18
Avg				34
Finished water				
1	247	191	0.76	24
2	13	3	0.23	77
4	23	6	0.25	75
5	6	3	0.50	50
Avg				57
Rivers				
1	132	74	0.56	44
2	69	31	0.44	56
3	47	43	0.92	8
Avg				36

* Sources are the same as those in Table 1.

Conclusions

From this preliminary report the following conclusions may be drawn:

1. Application of the molecular filter membrane with the LCC medium to the examination of surface, ground, and finished waters showed good correlation with results obtained using the MPN procedure.

2. The modified Endo medium containing 8-hydroxyquinoline (oxine) reduced considerably the noncoliform count frequently obtained on the membrane filter when certain waters were tested.

3. The membrane filter method using the oxine modified medium showed the presence of coliform organisms in many tests in which the MPN method failed to do so.

4. With the membrane filter method, approximately 81 per cent of the sheen colonies and approximately 22 per cent of the nonsheen colonies produced gas in lactose upon subculturing.

5. The membrane filter method permits the testing of a larger and more representative sample of water than the MPN method.

Acknowledgment

The authors wish to acknowledge the excellent cooperation of a number of water departments in providing water samples. They are especially indebted to Joseph A. McCarthy of the Lawrence Experiment Station, Massachusetts Dept. of Public Health, for his many suggestions in the course of the work.

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A Safety Program for the Water Works Industry

Task Group Report

A task group report presented on May 12, 1953, at the Annual Conference, Grand Rapids, Mich., by Raymond J. Faust, Chairman, Task Group A2.E—Safety Practices; Jerome Powers, Chairman A2.E1—Supply; Oscar Gullans, Chairman, A2.E2—Treatment and Pumping; Kenneth A. Day, Chairman, A2.E3—Distribution; and Rodney A. Edwards, Chairman, A2.E4—Administration.

Introduction

IN May 1950 the AWWA Board of Directors authorized a special task group to study safety practices in the water works industry and in allied utility fields. In its 1951 report (*1*), the task group pointed out that:

1. With some notable exceptions, the water works industry is not safety conscious.

2. The frequency rate of lost-time injuries (number of injuries per 1,000,000 man-hours) in water utilities in 1949 was 33, which compared unfavorably with that of other utilities: gas, 17; electric, 14; and communications, 2.

3. The accident severity rate (days lost per 1,000 man-hours) for the water works industry in 1949 was approximately equal to the national average for all industries.

Upon the recommendation of Wendell R. LaDue, Chairman, Committee on Water Works Administration, the Board of Directors, at its January 1952 meeting, decided to continue the study of safety practices for the water industry in more detail. Accordingly, it authorized four task groups to study safety as it applies to: [1] supply; [2] treatment and pumping; [3] distribution; and [4] administration. Before presenting reports on these subjects, the task group wishes to review the general problem of selling safety to the water industry.

Selling Safety

To sell safety, one must first know what it is. Safety has been defined as "a happy condition of man and [industrial] plant, created through personal effort directed toward the goal of conserving manpower through the elimination of man-made mistakes, commonly but erroneously referred to as accidents." That definition is simple and quite understandable. Surely its objectives are worth striving for.

As in any selling campaign, it is advisable to prove that safety programs pay handsome dividends. Fortunately, the evidence on that score is plentiful. Citing a few typical examples should prove helpful. Ramsey and Roose (*2*) state:

A check of the records recently showed that the cost of carelessness to the Kansas City Water Dept. for the period March–September 1952 was $4,360, compared to $16,473 for the same period in

1951. These costs included wages paid to injured employees while they were not working because of their injuries, doctor and hospital bills, and settlement of claims for injuries and damage to property. In 6 months, $12,113 was saved on these items, all of which are directly affected by a safety program. In addition, employee morale and efficiency have increased tremendously. There is no adequate yardstick for measuring the monetary value of these assets, but it undoubtedly amounts to thousands of dollars a year.

At Akron, Ohio, it is reported (*3*) that: "The city has achieved a substantial reduction in workmen's compensation premiums. In 1937 the city paid a premium of roughly $49,000, or a rate of $2.28 per hundred dollars of payroll. As of 1949 the rate is $0.53 per hundred dollars of payroll, a reduction of 76.7 per cent." Parenthetically, it must be remembered that medical and compensation expenses constitute only one-fifth of the total cost of accidents—the indirect costs are four times as great.

In 1949, Oakland, Calif., "made $1.00 for every 5 cents spent on employee accident prevention during the last year" (*3*), a 2,000 per cent return on its expenditure. Detroit had no general safety program from July 1, 1941, to June 30, 1944. "During that time compensation and medical costs increased 15.59 per cent. . . . During that same period the Department of Water Supply for Detroit started a safety program. The department's compensation and medical costs *decreased* 23.4 per cent during the time that the unprogrammed city was *increasing* 15.59 per cent" (*3*).

Such evidence should convince any city council or water works superintendent of the financial benefits obtainable from an active safety program.

In an effort to sell safety, it will be wise to call attention to the relatively small capital investment required to start a safety program. For the great majority of water utilities, only two ingredients, neither involving much money, are needed to launch a safety program: [1] an enthusiastic manager or superintendent who is sold on safety, and [2] a record of accidents, to assist the manager in learning why they happen and how to avoid their repetition. As the first item, the superintendent's enthusiasm for safety, cannot be reduced to dollars and cents, it must be recorded as a "no cost" item. The second, record keeping and interpretation, is also low in cost. Record sheets are about the only item needed, and they may be purchased from the National Safety Council, 425 North Michigan Avenue, Chicago 11, Ill., at a cost of only $1.05 for a pad of 50. For most plants that investment in record sheets should last for 10 years or more, making the cost 10 cents per year.

The capital cost of installing a safety program is obviously small. Relatively, that statement is also true for the largest utilities, as evidenced by the quick monetary returns at Kansas City, where a full-time safety director was employed. Consequently, the initial capital investment cannot be considered a deciding factor in determining whether to establish a safety program.

Conclusion

The water industry needs a safety program. Safety saves money, and it costs practically nothing to launch a safety program.

It is fair to conclude that safety helps the workers, the industry, and the profits—everybody wins! The key to winning these benefits is a superintendent

who is really sold on safety. The rest follows naturally.

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Supply Safety

Task Group A2.E1 is concerned with accidents occurring during operation, maintenance, or construction of source of supply facilities, including wells, intakes, reservoirs, reservoir lands, raw-water conduits, and the like. The normal hazards encountered in operation usually differ from those in maintenance and construction. Operation is often an individual effort, while maintenance and construction generally involve a group of workmen, although a single operator may make minor repairs and adjustments. Some hazards are, of course, common to all three types of activity.

A task group questionnaire sent to 277 cities with populations ranging from 10,000 to 500,000 was returned by 175 water plants, 39 of which reported lost-time accidents in 1951 and 1952 involving source of supply. Of these 39, 11 had no accidents in 1951. Out of 202 accidents reported for that year, 177 resulted in lost time. During 1952 there were 222 lost-time accidents in a total of 246. The distribution of accidents by age groups is shown in Table 1, and the principal types of injury are listed in Table 2.

TABLE 1

Distribution of Accidents by Age Groups

Age Group	No. of Accidents	
	1951	1952
15–20	1	5
20–25	6	6
25–30	13	15
30–35	18	20
35–40	13	23
40–45	24	16
45–50	87	81
50–55	17	15
55–60	13	16
60–65	5	19
65–70	3	4
70–75	2	2

TABLE 2

Types of Injury

Type	No. of Cases	
	1951	1952
Strains and sprains	40	32
Cuts and splinters	20	14
Skin eruptions (due to insects, ivy, etc.)	12	5
Hernias	8	2
Fractures	2	5
Eye injuries	12	11
Bruises	4	9
Infections	1	3
Frostbite		2

These accident statistics emphasize the desirability of developing a safety program and a manual of safe practice to cover the source of supply, as well as every other, phase of water works operation.

Treatment and Pumping Safety

In any safety program, the analysis of the causes of accidents ranks high among essential activities. Experience shows that such analyses bring to light many contributory factors that did not at first appear on the surface. Several common occurrences will illustrate this point.

1. The operator in charge of chemical equipment in a water plant discovered that he could clean his feeders much more quickly by using a homemade affair employing a jet of compressed air to blow the material out. He decided that it was easier to sweep the resulting dust off the floor than to clear it out of the feeder with a small brush. This labor-saving device worked successfully for approximately 6 months. The operator was rather proud of his accomplishment, but he had overlooked a most important factor—safety. Of course, he knew that fairly large pieces of solid alum flew around his head when the air hose was used, but he felt that, as long as he was wearing spectacles and the dust was not too bad, he could stand it for the short time required to clean the machine. He learned his lesson when a sharp piece of alum ricocheted off the side panel of the machine and entered his eye at a point where his glasses offered no protection. Medical treatment was unable to prevent permanent injury. If this man had received even a small amount of safety training, he would have known that it was a standing rule, for his own protection, to wear a dust mask and safety goggles in this type of work.

2. A mechanic was called on to make an emergency repair to chain-drive equipment. Because the machine was shut off, he assumed that it was perfectly safe to proceed with his work. While he was on the job, a friend walked up to inquire how the work was progressing. Suddenly the machine started up, just as the mechanic was removing the roller chain. As a result, he lost three fingers. This was modern equipment, equipped with all necessary safety devices and a push-button starting switch. An analysis revealed that the friend had accidentally leaned against the push-button switch and that the main switch had been left in the "on" position when the machine was shut off. The blame was therefore shared by the friend, who inadvertently pushed the starter button; the mechanic, who did not check to see that the machine had been properly shut off and the switches locked; and the operator, who failed to shut down the machine completely. The ultimate result of the accident analysis was the issuance of specific orders for the observation of proper safety precautions by all parties. When this type of machine is shut down or taken out of service, particularly for a repair operation, operators must be instructed that the switches are to be properly closed, locked, and tagged to indicate that repairs may be begun with safety. Mechanics must check these items before starting work on the equipment. Finally, other workers should be on the lookout for unsafe practices and call them to the attention of those immediately concerned.

3. A chemical operator making his usual rounds thought he saw a slight drip from one of the pipes leading from a sulfuric acid storage tank. Be-

lieving the valve might not be closed tightly, he reached up to close it. The valve broke off in his hand, and several gallons of concentrated acid poured out, some of its splattering on his face, hands, and clothing. When asked why he had not put on his safety clothing, which was in a locker at his elbow and included a rubber apron, a face shield, and rubber gloves, the operator replied that he thought the tank was empty. The lesson is that equipment should be checked frequently and thoroughly, and that safety precautions for handling dangerous chemicals must always be observed.

4. During the cleaning of settling basins, it was customary to send in labor crews with high-pressure hoses to complete the job. As the basins were two stories high, there was an 18-ft drop on each side of the upper level. The supervisor thought that all personnel had been thoroughly cautioned to stay away from the edge, particularly with the floors in a slippery condition, but a man recently hired had been added to the crew and knew nothing of the danger. Leaving the lighted area to explore, the man stepped off the upper platform in the darkness and fell to the concrete floor below, suffering numerous broken bones. A few words of caution could have prevented this accident, but the supervisor was also at fault in not ordering safety ropes placed in each basin at all danger points, a precaution that has since been adopted. When a potential hazard is noted immediate preventive action should be taken.

Many similar instances could be cited. Accidents can happen at the most unexpected times and places. Every effort must be made to anticipate them. The ability to recognize danger points and potential hazards comes gradually, with training and experience. Sometimes personnel are so accustomed to seeing the same things and doing the same things routinely, day after day, that they may reach a point where they cannot see the forest for the trees. In such circumstances, a one-man safety committee or a safety supervisor cannot adequately cover the ground, even in the smaller plants, but he can lay the foundation for good safety training, first by training himself, then his coworkers and supervisors, and, ultimately, all of the employees.

This sounds like a complicated procedure and, of course, cannot be accomplished overnight. In due time, however, even the lowliest laborer or janitor can be educated to become safety conscious in everything that he does.

Chicago Program

Perhaps this observation can be illustrated by the development of the safety program at the Chicago South Dist. Filtration Plant. In 1949 definite action was taken to start a safety organization. The literature (*1, 2*) was studied, and information on methods of setting up a safety organization was obtained from other installations. The preliminary committee held a long meeting and decided on a safety program that would eventually involve all employees working in the plant. This did not mean that they were all immediately placed on a safety committee, but the membership, including supervisors, mechanics, technical engineers, and laborers, was rotated every three months, except for a permanent secretary. This type of committee not only serves to cover the field of activities, but also brings in valuable advice on safety practices from each

department or section. As fewer than 30 per cent of the entire group of 160 employees could be assembled on any occasion, safety meetings for employees were repeated as many as four or five times to cover all personnel.

In addition to the general campaign carried on by the supervisors for the gradual education of all personnel in safety practices, the plant safety committee made studies of possible hazards. The early recommendations naturally dealt with the more obvious conditions, and rapid action was usually taken. Emergency litters and fire blankets, formerly locked in a storeroom, were placed in strategic locations in the plant, so that they would be readily available. First-aid cabinets were ordered for all parts of the plant that did not have them. A cabinet was installed in the chlorine room for the storage of gas masks, safety devices, and first-aid material. A special building was constructed, at a proper distance from the plant, to store flammable materials, solvents, and the like. Orders were issued for the installation of handrails and safety ropes where needed. The entire sulfuric acid system was inspected, cleaned, and repaired. Flushing lines and showers with quick-opening valves were installed at acid handling points.

With these steps, as well as the general recognition of a number of other existing hazards, it was felt that a good start had been made on a safety program, although the plant safety committee warned that "it will be up to the energy and vigilance of future members of the committee to seek out and make recommendations for the many safety problems that [still] exist in the plant." Since that time the subsequent committees have done an excellent job in analyzing hazardous conditions and making recommendations for improvements and the development of safe practices. By rotating the personnel, each man not only gets an opportunity to serve on the safety committee and benefit from safety education but also enjoys the great satisfaction of helping others to work safely.

TABLE 3

Chicago South Dist. Filtration Plant Safety Records

Year	No. of Employees	Total Exposure Time *hr*	No. of Injuries	Time Charges *hr*	Frequency	Severity
1952	156	340,000	3	15	8.8	0.044
1951	156	340,000	3	39	8.8	0.110
1950	160	340,900	5	389	14.7	1.140
1949*	162	340,704	4	207	11.7	0.611

* Plant safety program started.

Table 3 presents some data from the plant safety record since 1949. It will be noted that the record for 1949 was not too good and that it was still worse during 1950. The record for 1951 and 1952 was progressively better, however. This confirms a previous statement that a safety program must be carried on continuously and vigorously, for any laxity can cause trouble.

The first tendency of every safety committee is to correct the principal and most obvious hazardous conditions.

To seek out the minor hazards, which are often concealed or rooted in habit, to select the right person for the job to be done, and to prevent personnel from tinkering with unfamiliar equipment requires experience and analysis. It might be supposed that, after 4 years, the plant safety committee would have run out of ideas and recommendations. On the contrary, however, at the 1953 meeting of the safety committee, 35 items were brought to the attention of the supervisors, eight of which were for immediate action and the remainder for investigation by the maintenance crew in the normal course of operations. This serves to illustrate that the implementation of any safety program must be continuous and unrelenting.

Safe Handling of Chemicals

One of the outstanding examples of what has been already accomplished is the development of safe practices in the storage and handling of chlorine. This chemical was recognized early as one of the greatest hazards in the water works industry (*3*) and a great deal of time and effort was spent on this problem, with excellent results. Methods for the safe storage and handling of ammonia and caustic soda have also been established. Less frequently mentioned are sulfuric acid and lime. Other chemicals likewise deserve attention.

Quicklime

Quicklime has caustic properties similar to, but somewhat milder than, caustic soda and, therefore, presents a lesser handling hazard. In unloading bulk or bag material, the operators should wear long-sleeved, heavy clothing, bandanas, trousers tight around the shoe tops, goggles, and dust masks. The same type of equipment should be worn when loading chemical hoppers or bins, even though dust collectors are in operation. Quicklime dust, in combination with perspiration, can produce serious skin burns. Lime burns should be treated in the same manner as any other caustic burn, by thoroughly washing the affected area with soap and water and by neutralization with weak acetic acid. Personnel should be instructed to take a good shower after handling this material.

The operation of lime slakers also presents a hazard. To protect against spatter, goggles or face shields and rubber gloves should always be worn when inspecting lime slakers or lime lines in operation. The water supply to lime slakers should be closely watched, as an interruption while the lime continues to feed may create explosive temperatures. Mixtures of dry alum and quicklime can also generate heat and explode.

Aluminum Sulfate

Aluminum sulfate presents no great hazards in handling, but dust respirators should be worn when handling bulk alum or transferring the material from bags to bins or hoppers. Dust collectors on handling and feeding equipment are a necessity. Occasionally minor alum burns occur when hot weather causes excessive perspiration. Cleaning of alum feeding machines with compressed air should be prohibited except when proper safety equipment is worn. Vacuum cleaners serve the purpose much better. Alum bins or hoppers should always be cleaned by two men, with one acting as a safety man while the other descends into the bin or hopper. In such operations, goggles and dust masks must be

worn. Rules for servicing alum feeding equipment are as rigid as for any other mechanical device.

Activated Carbon

The handling and storage of activated carbon is generally accompanied by a certain amount of dust. Although the inhalation of carbon dust is not known to be injurious, dust masks should be worn when unloading or handling bags or bulk carbon. Unlike some other dusty materials, mixtures of activated carbon dust and air have not been found explosive in tests conducted by carbon manufacturers.

When ignited, activated carbon burns without producing smoke but creates intense heat. Carbon fires are thus sometimes difficult to detect and handle, particularly in large storage bins or stacks. The best method of storage is to have double rows of bagged material with aisles between them, so that they can be frequently inspected and any burning carbon can be reached without moving a great deal of material. Carbon storage areas must also be kept free of other flammable materials. Of course, smoking should be prohibited in such areas. Chlorine compounds or oily rags covered with activated carbon may cause spontaneous combustion.

Carbon storage bins are usually equipped with built-in carbon dioxide fire extinguishers. Open-storage carbon fires are more difficult to control. A small fire, involving one or two bags of carbon, can best be handled by removing the burning material to a safe place, using long-handled shovels and steel wheelbarrows. A large stream of water should never be played directly on the burning carbon, as it tends to spread the fire by causing burning particles to fly in every direction. Water fog nozzles or carbon dioxide extinguishers are most effective in controlling the fire. As a considerable amount of oxygen is adsorbed in the pores of the material, however, it can continue to burn even in the absence of air from the outside. Once the surface fire is quenched, therefore, the carbon should be completely soaked with cold water to reduce its temperature below the ignition point.

Ferrous Sulfate

Although ferrous sulfate is not toxic, it is irritating to the skin and mucous tissue because of its anhydrous and acid nature. It is much the same as alum, but differs in having more fine dust, so that more of it can come in contact with perspiration and saliva. Long sleeves should be worn to minimize the exposed area of skin, and a cream should be applied to the hands and face to protect against the dehydrating effect. Chemical goggles and a dust mask must be worn. Excessive dusting of ferrous sulfate handling or feeding equipment should be avoided. Ferrous sulfate dust is hygroscopic and, when slightly moist, becomes an excellent conductor of electricity. Consequently, open electric motors should be covered with dusttight hoods or replaced by totally enclosed motors. The same type of equipment is necessary where there is carbon dust.

Other Safety Measures

A number of safe practices should be repeatedly impressed on the minds of workers:

1. Open manholes and drains should be protected by guardrails or gratings.

2. Rolling scaffolds with guardrails should be used for high work in place of long ladders.

3. If a ladder is used, it must be in good condition and securely anchored.

4. Machinery should be shut down, and a thorough check made to see that switches or valves are locked in closed position, before work is started on the unit.

5. If hoisting equipment or chain falls are necessary, they should be examined to ascertain that they are in good working order and securely fastened and that the slings used are adequate to carry the load.

6. Proper tools should be available for the job, including protective goggles or eye shields and good lighting for repair operations.

Boilers

Good safety training is especially important around the boiler room or heating plant. Frequent boiler inspection and testing of safety devices, water level alarms, and gages should be mandatory. When performing maintenance and repair operations, every precaution should be taken to make sure that the equipment is not under pressure.

Pumps

Pumping equipment has its proportionate share of hazards and dangerous operations. One of the most important items, and one that has received extensive consideration, is the need for adequate safety guards on pump couplings.

Whether steam or electric, pumps are a vital part of every water system and must be kept in good operating condition at all times. Old-style pumping equipment was built for ruggedness and efficiency, with little regard for safety features. Apparently the manufacturer assumed that a man would know enough to keep his hands out of the moving machinery. The operator who polishes the shafts and coupling while the pump is rotating at high speed is risking the loss of a hand or arm, or even his life, just to get a compliment from the boss.

It is not necessary to build a cage around the whole pump, but a simple wire screen or sheet-metal guard around the coupling and moving parts, bolted down so that it cannot be lifted off, will generally serve to keep hands off moving parts until the pump is shut down. When there is danger of injury in testing pump bearings for overheating, it may be necessary to build a shielded sleeve around the bearing housing to prevent the operator from getting his hand near the moving machinery. Such a shield is particularly advantageous when it is necessary to reach over a belt drive or flywheel. Many large types of electric motors have open commutator sections and large openings for cooling. These should be covered with wire mesh guards. As a further precaution, it may be wise to post a conspicuous sign on the machine saying: "Don't Touch Moving Machinery Unless You Intend to Commit Suicide."

As a result of pressure from safety groups, many manufacturers of machinery and pumps have incorporated new safety features in this equipment within the last few years. Pump couplings of new design all have smooth surfaces with no keyways or protruding belts that can catch a man's hand or clothing. Proper safety guards are sometimes standard equipment on new models, and the manufacturers are to be complimented for adding these safety features. Even though a water plant cannot afford to junk its old

equipment and replace it with modern machinery, it is still possible to employ safety guards to eliminate all hazards and to train the operating and maintenance personnel.

When buying new pumping equipment and appurtenances, it is desirable not only to check performance ratings and efficiency but to have an expert look over the safety features as well. A careful survey of the location at which the equipment is going to be installed should also be made. The expert should make sure that the drive belt, flywheel, and coupling guards are adequate and should decide what other safety features, such as railings, will be needed. The latter can then be installed with the equipment.

When the aisles between pumps or operating equipment are narrow, as is common in many water plants, suitable guards and removable handrails should always be present. Facilities for locking switches or valves when cleaning, maintenance, or repair work is to be done on pumps or machinery should be provided. As an added precaution, a warning "Hold" tag should be put on the locks, switches, and valves.

Pressure Lines

Steam, hydraulic, and air pressure lines always constitute a hazard. In this field, the original designers can play a big part in the installation of safety features. Approved hand valves and automatic check valves should be included, to allow portions of the line to be isolated or taken out of service for repairs without shutting down the whole system. Also, frequent blowout or bleeder points should be provided, so that the pressure can be safely released before work starts on the line or equipment; these valves should remain open while the job is being done. A leaky shutoff valve, particularly in steam and compressed-air lines, can build up pressure in a closed system. A check should be made to be certain that the pressure is off before work is begun.

Electrical Equipment

Electrical equipment and wiring should always be installed in accordance with recommended safety practices. Modern high-voltage and switchboard equipment is normally designed for safe operation, but there is still a considerable amount of antiquated equipment in older installations that needs a good safety inspection. Open bus bar installations around transformers and pumps have always been a serious hazard, as have unprotected switches. Metal objects falling on unprotected circuits have put many pumping stations out of commission for several hours or days and have resulted in death or injury to personnel. Wiring circuits in pipe and filter galleries subject to moisture and condensation should be thoroughly grounded to prevent shocks. Frequent checks must be made to ascertain that the grounding is in working order and that the operator understands the precautions needed in operating or handling damp switches and motors.

Extension wires, temporary connections, and cords for small portable tools should always be properly grounded. Protective covering should be provided for wires laid on the ground or floor, or else they should be hung safely and securely overhead. Wires should not be draped over metal pipes or on nails where there is a chance for a short circuit. Extension cords must not be placed in water or on a wet floor.

Rubber gloves are required for high-voltage operation and rubber mats on floors at switchgear.

No one should tinker with or attempt makeshift repairs to electrical equipment unless he thoroughly understands what he is doing and knows all the necessary safety precautions. One wrong move by the tinkerer can cause injury to himself or ruin valuable equipment.

Emergency Repairs

The chances that intelligent people will take when making emergency repairs and working under mental pressure are innumerable. Tenseness nearly always leads to errors in judgment and action. The supervisor or foreman must be especially alert at these times to maintain safety discipline. He must "size up" the job at the start and determine the safest way to do it quickly.

Conclusion

The ultimate test of whether a safety program is working does not depend entirely upon statistics. It is to be found in the attitude of everyone in the plant, from the superintendent down to the lowliest janitor or watchman. There is no greater satisfaction than to know that the water treatment plant and pumping station have a good safety program and that everything possible is being done to prevent tragedy, heartbreak, and suffering.

Establishing a safety program involves learning how to locate and recognize accident hazards and determining the proper action to overcome them. It is believed that the detailed information being gathered by AWWA task groups for subsequent publication will make possible the development of a good safety program specifically tailored to suit the types of operations in every water pumping and treatment plant.

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Distribution Safety

Task Group A2.E3 sent out questionnaires asking for circumstances and causes of accidents resulting in injury for the 3-year period 1949–51, as well as for opinions on the effectiveness of certain features of safety programs. Also solicited were suggestions for items that would help existing safety programs. Replies were received from approximately half of the 69 organizations to which questionnaire forms were sent. Only 20 water works returned the forms filled out in all respects. It is felt that the questionnaire was somewhat long and detailed, and the organizations that completed it are certainly to be commended for their trouble.

The results have been compiled and tabulated to show the various accident factors involved. Each factor will be discussed in turn.

Agency of Injury

The agency of injury is the object or substance that is most closely asso-

ciated with the injury, and that, in general, could have been the subject of proper precautions (*1*). Examination of Table 4 shows that, of the thirteen agencies listed, hand tools, materials not otherwise classified, and working surfaces were most often involved in accidents. In fact, these three classes accounted for more than half of the injuries. The agency termed "trench or opening" might be included within the working-surface classification.

TABLE 4

Agency of Injury

Agency	No. of Injuries			
	Population Served by Plant—1,000's			Total
	30–100	100–500	Over 500	
Hand tools	30	186	531	717
Materials not otherwise classified	15	186	410	611
Working surfaces not otherwise classified	3	97	212	312
Machinery, pumps, and prime movers*	17	72	108	197
Trench or opening	22	107	65	194
Vehicles*	7	71	114	192
Boilers, pipes, and pressure vessels*		6	52	58
Elevators and hoisting apparatus*	2	22	24	48
Transmission apparatus*		21	2	23
Electrical apparatus*		11	8	19
Chemicals	1	6	11	18
Conveyors*	1	2		3
Miscellaneous	24	192	117	333

* Reference for Table 5.

Not many hand tools can be guarded while in use, but, if they are in good condition and used correctly, there should be no hazard. Handling materials, especially heavy, bulky objects, can lead to injury if safe practices are not followed. Safe procedures reduce the possibility of injury more than mechanical guards. Accidents associated with working surfaces can often be prevented by mechanical measures, although it is still necessary to prevent the unsafe act of the person involved.

Employee Activity

The activities in which employees were engaged when accidents occurred are given in Table 5. The injuries for each type of activity are shown as a percentage of all injuries. This table confirms the conclusion drawn from Table 4 that manual operations—pushing, pulling, striking, lifting, lowering, or carrying—account for a large percentage of injuries.

It should again be stressed that, in water distribution, safe procedure and attitudes in performing the most elementary tasks will eliminate a large portion of the injuries.

Type of Accident

The type of accident is the manner of contact of the injured person with an object or substance; or the expo-

TABLE 5
Employee Activity

Activity	Per Cent of All Injuries		
	Population Served by Plant—1,000's		
	30–100	100–500	Over 500
Pushing, pulling, or striking	25.4	23.8	29.9
Lifting, lowering, or carrying	27.0	23.8	26.8
Operating, working with, or riding on various agencies*	12.7	15.6	14.6
Walking, running, etc.	4.8	11.5	12.3
Standing or sitting still	3.2	9.0	10.2
Not otherwise classified	26.9	16.3	6.2

* Refers to agencies marked with * in Table 4.

sure or movement of the injured person that resulted in the injury (*1*). The most frequent type of accident reported in the survey (Table 6) is that in which the injured employee was struck by a falling, sliding, flying, or moving object. Almost one-quarter of all accidents fall into this category, which may involve most of the agencies in Table 4, especially hand tools and materials. Many accidents were of the "struck against stationary object" type, such as might occur when a wrench slips and the worker's hand hits a rock.

Whatever the type of accident, the seriousness of the injury will be determined by many factors. In a fall,

TABLE 6
Type of Accident

Type of Accident	No. of Injuries			
	Population Served by Plant—1,000's			Total
	30–100	100–500	Over 500	
Struck by falling, sliding, flying, and moving objects	25	229	448	702
Struck against stationary object	3	122	358	483
Slips (causing strains)	22	77	206	305
Caught in, on, or between	12	119	130	261
Falls (same level)	6	49	110	165
Burning and scalding		24	56	80
Poisoning		40	18	58
Animal bites		28	12	40
Inhalation, absorption, and swallowing		27		27
Electrical shock			1	1
Drowning or asphyxiation				0
All others	38	226	178	442

for instance, these factors would include the distance fallen, the material landed on, the position of the body as it lands, and the physical condition of the individual. An accident that will not even injure one employee might kill another. A minor scratch that becomes infected could cause the loss of an arm. As severity depends so much on chance, most organizations work on reducing the frequency of accidents, hoping that the severity will be correspondingly lessened.

Mechanical and Personal Causes

The mechanical causes of accidents and the percentage of injuries for all water works reporting are shown in Table 7.

The personal causes of accidents are: [1] physical or mental defects; [2] lack of knowledge or skill; and [3] improper attitude or chance taking. These factors apply both to the injured person and to others involved. No tabulation is presented because the compiled results showed that, in 65 per cent of the accidents reported, either there was no personal cause or the data were insufficient to classify. The sketchy replies indicate that this type of analysis was not being made by the water plants. It is difficult to imagine that the large number of hand tool accidents could have occurred without personal factors operating in addition to mechanical causes. For example, if an employee uses a chisel with a mushroomed head and is cut by the sharp burrs, the causes are both defective equipment and improper attitude.

Accidents in which neither mechanical nor personal causes were at work fall within the "act of God" classification and happen so seldom that this category may be ignored.

Features of Safety Program

Although small water works cannot maintain an elaborate safety organization or program, certain basic elements and functions can be assigned to responsible existing personnel. The National Safety Council lists (*2*) these basic elements of safety organization:

1. Management leadership (assumption of responsibility and declaration of policy)
2. Assignment of responsibility (to operating officials, safety directors, supervisors, and committees)

TABLE 7

Mechanical Causes

Cause	Per Cent of All Injuries
Improper guarding	3
Defective substances or equipment	4
Hazardous arrangement	7
Improper illumination	0
Improper ventilation	0
Improper dress or apparel	11
No mechanical cause	58
Insufficient data to classify	17

3. Maintenance of safe working conditions (inspection, engineering revision, and purchasing)
4. Establishment of safety training (for both supervisors and workers)
5. Accident record system (reports of injuries, accident analysis, and measurement of results)
6. Medical and first-aid system (placement examinations, treatment of injuries, first-aid services, and periodic health examinations)
7. Acceptance of personal responsibility by employees (training and maintenance of interest).

Fourteen more detailed features were included in the task group's questionnaire, with the request that the responding water works organization rate them in order of importance and also evaluate them as "necessary," "helpful," "doubtful," or "not needed."

TABLE 8

Rating of Safety Features

Features of Safety Programs	Weighted Rating	Necessary	Helpful	Doubtful	Not Needed
1. Training of supervisors	251	18	3	0	0
2. Interest of administration maintained	202	14	6	0	0
3. Machine guards and personal protective equipment used	188	19	2	0	0
4. Good housekeeping maintained	169	15	5	0	0
5. Careful selection and placement of workers	168	12	5	1	0
6. Elimination of hazardous processes	158	14	6	0	0
7. Employee safety meetings, films, etc.	158	9	9	2	1
8. Published safety rules, with enforcement	155	10	7	3	0
9. Reports, investigations, and analysis of accidents	133	8	10	1	0
10. Safety inspections	115	8	11	0	0
11. Safety posters and bulletins displayed	114	5	11	4	0
12. Full-time safety supervisor or director appointed	97	9	5	3	3
13. Effective first-aid service in use	95	7	10	1	2
14. First-aid classes	67	2	12	5	1

Additional Features Suggested

Feature	No. of Replies Suggesting
Safety committees	3
Awards for safety results	3
Participation in local, state, and national safety organizations	2
Safety suggestion system	1
Safety "scoreboards"	1

"time safety supervisor or director appointed," seems to have caused the greatest variation of opinion, undoubtedly because the size of the organization will largely determine the necessity for such a position. Some fairly large utilities, however, have been able to integrate safety into the task assignments and job procedures of their line supervision so that a separate safety unit is not used. This is the ideal plan but requires a strong policy, adequate training, and constant attention to overcome the usual tendency to consider production first and safety sec-

The results are shown in Table 8. It will be noted that the weighted ratings coincide reasonably well with the evaluations.

There was substantial agreement on the need for the first six features listed. The remainder were generally considered helpful. The feature, "full-

ond. The additional features suggested in the replies received are all excellent and should have been included in the original questionnaire.

Training Aids

The questionnaires contained the heading: "There is a need for the following items to help our safety program." The items listed in various replies included:

1. "Sound motion pictures on all phases of water works operations."
2. "Better training and testing of drivers."
3. "Further training of field supervisors in job evaluation and employee relations."
4. "More intensive training programs for supervisors and cooperation and support of same."
5. "All-level cooperation."
6. "Continuous, repetitive application of our slogan, 'Attitude, ability, and attention the basis of accident prevention.'"
7. "Specialized training aids for water works employees and supervisors."
8. "Printed and visual aids designed for water works problems."

Six of these eight comments mention the need for training aids aimed at water works personnel. This fits in well with the importance given to the "training of supervisors" feature of safety programs. The supervisor or foreman has been called (*3, 4*) the key man of industry, not only in production, but also in accident prevention. There is a need, then, for aural and visual aids to train the water works supervisor and foreman so that he can do a better job of breaking in, training, and supervising employees to work safely.

The training aids should apply to water works operations specifically, if possible. If a foreman of underground work is shown a film made in a factory, he tends to be dubious of its usefulness in his work, even though the principles are valid. It is vital to teach the foreman how to instruct and train his men. To hand the usual first-line supervisor or foreman a manual to study would in most instances be ineffective.

Summary

From the replies to the questionnaires sent out by this task group, it appears that the injuries to employees have been most frequent in elementary manual labor, using hand tools and handling materials. The workman is usually injured by being struck by some moving object or by striking against something. Chance taking is the most common personal factor causing accidents, with lack of knowledge or skill second. Many features of safety programs are helpful in reducing accidents. Suggestions made by replying organizations, however, indicate the desirability of concentrating on devising specialized training material to assist water utilities in starting and operating a safety program.

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Administration Safety

The assignment of Task Group A2.E4 is the collection and analysis of data on accidents involving office personnel of water utilities. The period covered was 1949–52, although, because of the mailing time of the questionnaires sent out by the task group, only 50 out of 95 usable returns contained information on the 1952 record. Thus, it should be kept in mind that all subsequent figures given reflect aggregates for approximately 3½ years—that is, the figures represent 4-year aggregates for 52.6 per cent of the reporting plants and 3-year aggregates for the remaining 47.4 per cent.

Questionnaires were sent to 155 water plants, 102 of which returned them. Of these, 95 were usable, while 7 did not contain sufficient data to warrant their use in this study. Out of the usable returns, 41 were from plants having safety programs, 11 from plants having partial programs, and 43 from plants with no safety programs. Consequently, 52.6 per cent of the final figures, and the conclusions based on them, reflect the experience of water works under some degree of safety promotional influence.

The 95 water plants submitting usable questionnaires employed a total of 4,835 office workers, 113 of whom had some outside duties. (The latter figure is not exact, inasmuch as some plants reporting office personnel with outside duties did not state the number involved.) Because the ratio of municipal to private ownership (84:11) in this group of 95 water works roughly approximates that in the country as a whole, and because the estimated population served (25,800,000) is approximately one-sixth of the national total, it is believed that conclusions drawn from the data obtained will generally be applicable to the entire industry.

TABLE 9

Distribution of Accidents

Item	With Program		No Program		Partial Program	
	Munic.	Pvt.	Munic.	Pvt.	Munic.	Pvt.
Number of questionnaire returns	32	9	42	1	10	1
Plants with no office accidents	8	3	25	0	7	0
Plants with no lost-time accidents	16	7	37	0	7	0
Plants with no office accidents—*per cent*	25	33	60	0	70	0
Plants with no lost-time accidents—*per cent*	50	78	88	0	70	0

Table 9 shows the distribution of accidents among the responding plants, classified according to ownership and existence of a safety program. It will be noted that, out of the 52 plants with some type of program, 18, or 34.6 per cent, had no office accidents and 30, or 57.6 per cent, had no lost-time accidents.

The causes and types of injuries are considered for the years 1949–52, the data for 1952 being incomplete, as previously mentioned. Because it would

have been superfluous to list the great number of odd or unique causes and types, only the principal ones are distinguished in Table 10. The unclassified causes include: foreign objects in the eye, uneven floors, pencil points, paper edges, splinters, movement of chair on rollers while employee was trying to sit down, window (closed on finger), broken desk glass, electric fan, and steel wool. Some of the unclassified injuries were: cuts, dermatitis, punctures, hernia, blisters, and infections.

There is undoubtedly a relationship between the totals of 96 accidents due to slippery floors and 185 bruises. Probably also contributing to the high bruise figure were the 49 open file drawer accidents. Table 10 indicates a yearly average of approximately 110 accidents and an equal number of injuries. Thus, each of the 95 reporting water plants might expect to have slightly more than one accident per year among its office workers.

TABLE 10

Causes and Types of Office Worker Injury

Item	1949	1950	1951	1952	Total
Cause of Injury					
Slippery floors	22	28	26	20	96
Obsolete furniture	8	5	6	3	22
Filing cabinets					
Open drawers	9	21	13	6	49
Overloading	1	3	3	2	9
Open doors	3	2	8	3	16
Electrical and mechanical office equipment	19	16	20	8	63
Improper illumination	1	0	0	0	1
Other	50	36	35	66	187
Total	113	111	111	108	443
Type of Injury					
Bruises	56	43	37	49	185
Burns	1	0	1	1	3
Sprains	15	20	11	21	67
Fractures	2	4	2	4	12
Other	42	50	40	41	173
Total	116	117	91	116	440

Table 11 shows the number of days lost in accidents involving office employees. The frequency and severity rates—3.514 and 0.034, respectively—indicate that there were 3½ lost-time accidents for every million man-hours worked, resulting in a loss of 34 days. These rates are good, compared with those for all water works employees, but the hazards involved are obviously

not so great. According to National Safety Council figures (*1*), the frequency and severity rates for all water utility employees in 1951 were 30.00 and 0.72, respectively; the corresponding rates for all industries in that year were 9.06 and 0.97.

Meter-reading Accidents

Although the responsibility for studying meter-reading accidents was assigned to Task Group A2.E4 too late for the subject to be included in the present survey, some data on this matter are available. Fifteen water plants reported a total of 357 accidents to meter readers in the period 1949–51. Of these, 158 were due to animal bites and 111 involved working surfaces (poor or slippery flooring, badly lighted areas, and the like). Both the accident ratios and the lost time per accident decreased as the size of the utility increased. It may be assumed that the larger utilities make a greater effort to prevent accidents than the smaller plants do. The incidence of dog-bite cases appears high enough to warrant further study of methods of reducing their number. The figures indicate that this type of accident occurs once in every 35,000 man-hours devoted to meter reading.

Conclusion

It may be concluded that office workers are exposed to fewer hazards and, therefore, suffer fewer mishaps than other employees. It also seems true that the injuries they do sustain are less severe, on the average. One point of caution is necessary. If any of the data presented seems to indicate a greater freedom from accidents in plants without safety programs than in those which have them, it must be remembered that the former may not keep records as religiously as the latter. There is a tendency to overlook or ignore many small and inconsequential accidents in plants that have no safety committeeman to check them and no safety forms to be filled out.

The desirable ends to be gained from a study such as this are a reduction in the number of office personnel injured and a determination to find and correct the most common and repetitious causes. It is unfortunate indeed that 88 persons in 1949–52 had to lose time from their jobs and suffer pain and other hardships when they were working in as safe a place as a water utility business office should be.

TABLE 11

*Lost-Time Office Employee Accidents**

Year	No. of Lost-Time Accidents	No. of Injuries	Days Lost
1949	22	119	195
1950	20	116	297
1951	23	115	199
1952	23	118	160
Total	88	468	851

4-year frequency rate: 3.514
4-year severity rate: 0.034

* Total man-hours worked, 25,042,000.

Reference

1. Faust, R. J. Application of Safety Program to Water Works Industry. *Jour. AWWA*, **45**:19 (Jan. 1953).

Status of Training Courses and Certification in the United States

Committee Report

A report of Committee G16—Uniformity of Grading, Registration, and Short Courses, presented on May 13, 1953, at the Annual Conference, Grand Rapids, Mich. The committee members were: Raymond J. Faust (Chairman), A. P. Black, Edward S. Hopkins, Fred Merryfield, and Edward R. Stapley.

Introduction

SHORT courses for treatment plant operators have a history of at least 30 years. Their initial objective was to give practical training in the art of water treatment, especially in disinfection and bacterial control, to an expanding number of men who found themselves faced with new problems of chemical application and control about which they had very little knowledge. Health department personnel and consulting engineers in the 1920's and 1930's recognized the benefits that water treatment could contribute to the health of the country and realized that the fulfillment of any program of insuring safe, clear, and palatable water supplies required competent control of water treatment at the local level. Training was needed to produce qualified operators as quickly as possible to meet the demand. That training was provided largely through short courses.

The training program has aided in the elimination of waterborne enteric infection. Today in-service training courses for water works personnel are to be found in almost every state in the country. Through the years, however, the scope of short-course training has changed considerably. Curricula now comprise a wide range of subjects, including disinfection, filtration, taste and odor control, hydraulics, fluoridation, meter operation and repair, main disinfection, pumping, feed control, bacteriology, biology, and chemistry. All branches of water works operations are covered—treatment, distribution, pumping, and administration. Courses on distribution and pumping are relatively new, while in-service training for management is even more recent (Illinois in 1952 and Iowa in 1953).

Certification of the qualifications of treatment plant operators by state health departments was another program instituted to help protect the public health through assuring adequate treatment and control of water supplies. Without competent control, water treatment could not be depended upon to produce a continuously safe supply. Thus, certification of treatment plant operators has proved to be an end result of in-service training. At present 23 states have certification programs.

In-service training and certification of treatment plant operators have performed an outstanding service to the country in assuring safe water everywhere. That work must continue. Moreover, interest in the training of distribution system personnel must increase. The need for this type of training is most apparent during periods of national emergency, when lives and homes depend to a large degree on the skill and resourcefulness of distribution system maintenance men. They need practical demonstrations in how to meet unusual circumstances and now is the time to train them. The need for training water treatment plant operators is readily understood and generally accepted. The need for training distribution system personnel has not been so clearly understood but of late is being accepted in many localities, and an increasing number of short courses on the subject have been prepared.

Management remains the one branch of water utility operations in which personnel have not received specialized training—a most unfortunate situation. There are many signs that management needs training of the highest order in such subjects as finance, public relations, safety practices, master planning, business administration, engineering, water treatment, rate structures, and salesmanship. Here is a training field wide open for exploration. Certainly, its development will yield returns even greater than those now recorded for the other branches of the industry. Illinois and Iowa are pointing the way.

Even a cursory survey of water systems will show glaring weaknesses in too high a percentage of them. Such deficiencies as shortages of supply, use of less than recommended treatment, appalling wastage of water in distribution systems and at customer taps, inadequate financing, lack of adequate expansion, and absence of master planning for the future are largely due to inadequate leadership in water utility management. The conclusion must be that much of the industry needs upgrading. The place to attack such a problem is at the top and the approach should be through education. The objective of the Association should be to recommend the qualifications for management personnel. And those qualifications should be high, particularly as they relate to education. Unquestionably, more college-trained men are needed in the water works industry. Attracting them presents a challenge that the industry must act to meet.

Philosophy of Training Program

The objectives of a well-rounded short course are: [1] to improve the group level of occupational efficiency; [2] to acquaint the group with new developments; [3] to develop among the members of the group a concept of their individual responsibility to the community; [4] to develop among the members of the group a better understanding of human relations; and [5] to bring about an increased community appreciation of water works operation.

It seems appropriate to review the conditions in the water works industry that have resulted in the organization of short courses in 32 states and to ask to what extent the short course in its present form can serve to improve these conditions. In 1945 about 80 per cent of the 15,400 public water supplies in this country were in com-

munities of 2,500 population or less. A large percentage of these water systems are run by men unprepared by training to discharge effectively and intelligently the very important obligations and responsibilities inherent in their positions.

Conclusive evidence on this point is provided by a recent University of Florida survey of the educational background of 302 of the 750 water works operators in that state. The average age of these operators was found to be 44.3 years. Six have completed less than six grades in grammar school; 125 have completed work through the ninth grade; 138 have completed work through the twelfth grade; 16 have completed 2 years of college work; and only 16, or 5.3 per cent, hold college degrees. This situation is inevitably reflected in practically every survey having to do with the operation of water systems. For example, Gorman and Wolman (*1*), in their report on waterborne outbreaks, 1920–36, point out that "one of the most distressing aspects was the number of outbreaks due to apparent laxity in the operation of equipment. The human equation as a contributing factor was vividly portrayed in altogether too many instances." Eliassen and Cummings (*2*), in a later survey of waterborne outbreaks, state that none of the 327 outbreaks that occurred during the period 1938–45 "could be attributed to the inherent inability of a properly designed water treatment plant to handle the pollutional load. Rather, a failure of the human element to make the plant perform as it was capable of doing was responsible for many outbreaks."

The fact that the percentage incidence of waterborne disease has been reduced almost to the vanishing point has been due not only to technical developments in the art of water purification but also to the loyalty and devotion to duty of a large group of operators who, through their own efforts, have better prepared themselves to perform their duties.

It is extremely important to remember that small water systems do not imply either small problems or small responsibilities. Glace (*3*), discussing the design and operation of small water plants, has pointed out that the quality of engineering skill, as well as the total amount of engineering service used in the design of a small plant, is usually in proportion to the size of the works and that provisions for the control of water quality, other than bacteriological safeguards, are generally unconsidered except in plants with filters. One water works operator (*3*) has recorded the opinion that he found it easier to supervise the operation of an 8-mgd softening plant that included treatment units for boiler, air-conditioning, and deionized water than to operate, without specialists, a 0.25-mgd treatment plant. Herein lies the crux of the problem. The operator of the small plant, more often than not, finds himself in charge of underdesigned units with inadequate instrumentation, although his technical problems are often as great and his burden of responsibility is always as heavy as that of the operator of a large plant. The subject matter of existing short courses is indicative of the desire and the need of these men for a wide diversity of technical information in the field.

It should constantly be stressed that the employment of the technically trained man, at an adequate salary, is an economical procedure even in a small water system and will yield sub-

stantial financial returns. The per capita investment cost and the unit cost of operation are usually substantially higher for the small plant than for the large one. These facts constitute a challenge to the water works industry and to the Association. Subscribing to the principle of using short courses and similar agencies and devices for the teaching of nonprofessional and technically untrained water works operators and managers does not mean endorsing a situation that is not in the best interests of the community served, the public health in general, or the Association.

The Association should begin to emphasize more and more a carefully planned and aggressive program of public relations, the objectives of which should be the professionalization of the operational and management phases of the water works industry, with the eventual result that only technically trained men will be placed in charge of water works utilities, large and small. The Association should, however, vigorously pursue by all possible means an interim program of encouraging the further development of short courses and extension and correspondence courses. An ideal program of education for an adult group of the type involved would place the short course at the beginning of a well-planned interim program of study.

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Short Courses

Questionnaires on short courses were sent to the various AWWA sections for distribution. Information was requested on administration and course content, the latter being subdivided into basic science, technology, and subjects related to operation and minor administrative practices in the water works field. A condensed summary of the replies is presented in Table 1 of this report. No elaborate statistical analyses were made, as the data did not warrant such treatment.

Administration of Short Courses

Of the 32 short courses reported, 26 are held annually, 1 semiannually, 3 biennially, and 2 irregularly. They are sponsored by 36 universities and colleges, 17 AWWA sections, 29 state health departments, 14 operators' associations, 9 municipal leagues, and 3 state vocational education departments. The U.S. Public Health Service is also a sponsor.

Although a part of the expenses of the short courses is met by registration fees, the universities and state health departments carry the major portion of the financial burden. No data on the actual cost of such courses were obtained, but it is well known that many expenses are absorbed by the civil engineering and other departments of the universities and colleges. This is also true, to a lesser extent, for several state departments of health, which furnish part of the instructional

staff or equipment. Except in a few courses, the registration fees do not cover the cost of promotion, laboratory supplies, books, and stenographic help.

The expenses of the registrants for travel, lodging, and food are borne by both the individuals and the cities for which they work. This matter unquestionably involves administrative attitude and policy and, in smaller measure, the personal relationship between the individual and his superiors.

The length of the annual courses given ranges from 2 to 6 days, with 3- and 5-day courses being the most popular. Three courses are of longer duration and might well be classified as extension courses. The 31 courses

TABLE 1

Data on Short Courses

Sponsorship (31 Courses)

Type of Organization	No. of Sponsors
AWWA section	17
State health department	31
College or university	36
Operators' association	14
State municipal league	9
State vocational education agency	3

Financing (31 Courses)

Source of Financing	Major Financing	Personnel and Supplies	Total
AWWA section	3		3
State health department	8	6	14
College or university	17	4	21
Operators' association	5		5
State municipal league	1		1
State vocational education agency	1		1
Registration fees	24		24

Personal expenses (21 Courses)

Per Cent Paid	Individuals	Cities	Industries
100	7		
95		4	
90		5	
60		1	
50	4	4	
30			1
10	5		
5	5		1

Course Frequency (32 Courses)

Frequency	No. of Courses
Semiannual	1
Annual	26
Biennial	3
Irregular	2

Course Length (31 Courses)

Length *days*	No. of Courses
2	3
2½	2
3	10
3½	1
4	3
5	7
6	2
7–15	3

Attendance (30 Courses)

No. of Students	No. of Courses
10–25	5
25–50	4
50–75	2
75–100	7
100–125	6
125–150	1
150–200	3
Over 200	2

Educational Requirements (32 Courses)

Prerequisite	No. of Courses
None	27
Grade school	1
High school	4

TABLE 1—*Data on Short Courses (contd.)*

Examinations (32 Courses)	
Examinations	No. of Courses
Have*	11
Do not have	21

Course Content (32 Courses)		
Subject†	Courses With Major Emphasis	Courses With Minor Emphasis
Mathematics		
Arithmetic	6	6
Fractions and decimals	12	12
Metric system	6	6
Algebra		5
Geometry		1
Practical applications	19	3
Chemistry		
Valence	3	6
Atoms and atomic weights	5	5
Equations	6	10
Standard solutions	8	9
Chemical reactions	7	10
Laboratory control tests	26	1
General	9	6
Qualitative	2	3
Quantitative	3	4
Organic	1	2
Bacteriology		
Disinfection	13	5
Sterilization	8	7
Media	6	8
Laboratory technique	17	2
Coliform tests	17	5
Interpretations	16	5
Standard methods	15	5
Epidemics	6	9
Water treatment		
Turbidity	9	8
Sedimentation	12	7
Coagulation	15	5
Chemical handling	6	13
Chemical feeding	9	12
Water treatment (contd.)		
Softening (lime-soda)	9	11
Softening (ion exchange)	4	12
Toxic materials	2	10
Taste and odor	16	6
Color	5	9
Algae	11	7
Algicides	7	9
Trade wastes	5	5
Disinfection	25	1
Dechlorination	3	6
Fluoridation	9	12
Filtration	17	5
Corrosion	11	8
Iron removal	5	12
Engineering and Maintenance		
Hydraulics	13	5
Hydrology	4	7
Engineering materials	1	5
Maps and records	7	8
Maintenance and repair		
Meters	10	7
Mains	9	8
Hydrants	4	10
Valves	3	11
Feeding equipment	8	10
Packing materials	3	11
Water storage	5	11
Disinfection of mains	11	10
Pumps	15	5
Emergency operation	6	7
Pipe joints (types)	1	11
Trenching, shoring, etc.	2	6
Freezing, thawing		6
Plant design (minor)	3	5
Administration		
Accounting	1	5
Rates	2	7
Meter reading	2	4
Billing	3	4
Collecting	2	5
Office management	1	4
Depreciation	1	3

* Total students passing, 85 per cent.

† The following figures indicate the number of short courses that did not include the subjects listed: mathematics, 9; chemistry, 4; bacteriology, 7; water treatment, 2; engineering and maintenance, 3; and administration, 11.

TABLE 1—*Data on Short Courses (contd.)*

Subject†	Courses With Major Emphasis	Courses With Minor Emphasis
Administration (contd.)		
Labor relations	2	3
Public relations	12	7
Safety practices	5	8
Unclassified		
H_2S removal	1	
Plant maintenance	1	
Wells	3	
Cross connections	3	
Electricity	3	
Lubrication	1	
Stream measurement	1	
Controls	1	
Pumping and ground water	3	
Financing	1	
Economics of water softening	1	
Unclassified (contd.)		
Public health regulations and licensing laws	3	
Civil defense	2	
Radioactivity	2	
Microscopy	1	
Geology	1	
Field inspections	4	
Public speaking	1	
Water rights	1	
Legal rights of districts	2	
Specifications (AWWA)	1	
Fire protection	1	
Telemetering	1	
Mine acid problems	1	
Leak detection	1	
Stream pollution	2	
Plumbing	1	
Watershed sanitation	2	

totaled more than 150 days per year. Omitting the three longer courses just mentioned, more than 100 days of general short courses are given annually in the water works field.

Attendance

The attendance at the courses ranges from 16 to almost 600. In 1951 more than 2,200 water superintendents and operators attended water works short courses for a total of approximately 13,300 man-days. The effort expended by instructors on preparation of notes, provision of laboratory equipment and supplies, and arrangements for housing cannot be measured but is undoubtedly considerable.

Eighty-five per cent of the short courses given have no educational prerequisites, and only 12 per cent require a high school education. The problems of organizing lectures and demonstrations for students with a large diversity of learning can best be left to the imagination. The desire for knowledge on the part of many registrants with very little formal education is admirable. The absence of educational prerequisites does not imply, however, that many of the registrants do not have high qualifications. Unfortunately, this item was not covered in detail in the questionnaire, but it is probably true that the sponsors of the short course are anxious to help all who are interested.

Approximately two-thirds of the courses have no examinations. More consideration might be given to their use, principally to indicate weaknesses of instruction.

Course Content

Tremendous technical strides have been made in the water works industry in the past 30 years. Hindsight

makes it easy to say what should have been taught in high school and elsewhere, but the fact remains that many operators who do not have the necessary basic training are eager to learn. This desire must be satisfied.

The short courses emphasize the practical applications of mathematics, chemistry, and bacteriology which are basic to an understanding of the water works operator's job. Laboratory work in chemistry and bacteriology is particularly stressed.

Formal lectures in traditional divisions of these subjects are somewhat neglected, probably because of time and requirement limitations. It is evident that customary teaching methods and subjects are being revised in the light of previous instruction and experience in short courses. It is encouraging that so many operators want to learn more about community health and their responsibility in that regard.

The technique of water treatment is a very important subject. There are few short schools in which it does not occupy a major place on the program. Engineering and maintenance are less emphasized. Maintenance problems in a short course are probably best handled informally, by demonstration and free discussion. A debate on the type and amount of engineering that can be taught in a short course might easily be started, but unquestionably more attention could be paid to some engineering subjects.

There are probably two reasons why water works administration generally is not stressed. First, the excellent work of the AWWA Water Works Management Div. helps to fill this need; and, second, many of the participants are in submanagerial positions. By far the greatest number of administration courses are devoted to public relations.

The large range of subject matter, the fine attendance record, and the voluntary participation by registrants, instructional staff, and sponsors indicate that the short course for water works personnel is an important means of informal adult education.

"Special" and Extension Courses

Fourteen "special" courses other than short-school sessions are offered in nine states. With the exception of the "intensive training" program in Michigan and the 3-day utility management schools in Illinois and Iowa, these courses are merely a continuation of short-school sessions and should be considered as such.

They include chlorinating-equipment repair training (1 course); refresher in plant operation (5 courses); water system control for civil defense (2 courses). It is apparent that the subjects are selected in accordance with local needs or availability of facilities and have been developed to appeal to the individual without consideration of an overall comprehensive policy. This condition is illustrated by the fact that financial support is given by individuals rather than by state health departments and educational agencies. AWWA section participation was notably absent.

Extension Courses

The survey of extension courses, including correspondence courses, offered by various colleges and universities produced interesting results.

Questionnaires were returned from 174 colleges advertising extension courses. Ninety-seven institutions, or 55.7 per cent, offer a curriculum that would be of advantage to water works personnel. It should be noted that these courses are available in all sections except Arizona, Florida, Nevada, Tennessee, North Dakota, Massachusetts, New Hampshire, Vermont, South Carolina, and the Pacific Northwest. In each instance, colleges in these areas stated that extension courses would be made available if there were a demand for them. The geographical distribution of such courses is presented in Table 2.

Engineering and technical subjects are offered in many locations. In 58 per cent of the colleges, the bachelor degree is given after accumulation of credits from extension work, while another 21 per cent give credit for extension work but require additional residence for the degree. High school training or equivalent is necessary for college credit, but when credit is not desired, this prerequisite is waived.

TABLE 2

Distribution of Extension Courses in the United States

AWWA Section and State	Colleges Reporting	Colleges Offering Course
Alabama-Mississippi		
Alabama	2	1
Mississippi	2	2
Arizona	3	0
California		
California	10	8
Nevada	1	0
Chesapeake		
Delaware	2	1
Maryland	3	2
Dist. of Columbia	3	3
Florida	3	0
Illinois	6	5
Indiana	5	3
Iowa	5	5
Kansas	5	3
Kentucky-Tennessee		
Kentucky	1	1
Tennessee	1	0
Michigan	5	4
Minnesota		
Minnesota	1	1
North Dakota	1	0
South Dakota	3	2
Missouri	3	2
Montana	1	1
Nebraska	4	2
New England		
Connecticut	2	1
Massachusetts	4	0
Maine	1	1
New England (*contd.*)		
New Hampshire	1	0
Rhode Island	3	3
Vermont	0	0
New Jersey	3	1
New York	16	11
North Carolina	1	1
Ohio	13	6
Pacific Northwest		
Idaho	1	0
Oregon	2	0
Washington	3	0
Pennsylvania	10	5
Rocky Mountain		
Colorado	2	1
New Mexico	2	1
Utah	2	2
Wyoming	1	1
Southeastern		
Georgia	3	1
South Carolina	2	0
Southwest		
Arkansas	3	2
Louisiana	1	1
Oklahoma	6	4
Texas	12	3
Virginia	3	2
West Virginia	7	3
Wisconsin	1	1
Total	174	97

Data on types of courses and admission requirements are shown in Table 3.

Extension study is generally conducted in evening classes on the campus, but other periods are frequently utilized. Many colleges located in small towns have established additional training centers in large cities. Fifty-one per cent of those reporting have classes in one or more locations in addition to training on the campus (Table 4).

TABLE 3

Extension Curriculum Details

Course	No. of Colleges	Per Cent of Colleges Reporting
Chemical engineering	35	36
Civil engineering	40	41
Electrical engineering	42	43
Mechanical engineering	45	47
Sanitary engineering	14	14
Bacteriology	35	36
Biology	56	58
Chemistry	74	77
Mathematics	82	85
Physics	69	71
Degree		
Not given	20	21
Given	56	58
Prerequisite		
High school diploma	77	79
Equivalent examination	54	56
No requirement	6	6

It may be concluded that, with the exception of the states noted, extension courses are available throughout the United States and offer formal training in either engineering or science subjects that will benefit water works personnel. It is believed that the information obtained is sufficient evidence to justify the AWWA in establishing a program to encourage the development and use of such college courses.

TABLE 4

Location and Time of Extension Classes

Location	No. of Colleges	Per Cent of Colleges Reporting
On campus	84	87
Off campus	49	51
Time		
Evening	72	74
Afternoon	41	42
Saturday	35	36

Certification of Water Works Personnel

In 1935 only five states had programs for the licensing of water works employees—Michigan, New Jersey, Ohio, Texas, and West Virginia. The authority by which licensing or certification was carried out in these states varied widely. The Michigan certification program, for instance, had been in operation since 1931, under a state health department regulation. The New Jersey certification program operated under a state statute passed in 1918, while the Ohio program came under the registration law for professional engineers. West Virginia was pursuing its certification program under a law adopted in 1933, and Texas was using a voluntary licensing system supervised by the Texas Water Works Operators' Association. It is of interest to note that Michigan, Ohio, and Texas subsequently changed their authority for certification to state statute.

By 1952 the idea of certifying the qualifications of water plant operators

had spread to 23 states, 16 of which followed a voluntary plan of certification, while 7 operated under state statutes. The remaining 25 states had not attempted certification programs of any type. Table 5 gives some basic facts about the programs. A study of these data indicates that, under the voluntary certification plan, an average of 35.6 per cent of the eligible operators are certified. (This analysis omits Louisiana, Minnesota, Pennsylvania, and South Carolina for lack of information or because the programs have not been established long enough to produce a representative figure.) In contrast, the average percentage of eligible operators certified in seven states under the mandatory system is 94.7, more than 2½ times the average

TABLE 5

State Certification Programs

State	Year Program Started or Law Enacted	Administering Agency	Per Cent of Eligible Operators Certified
Voluntary Certification			
Alabama	1950	Ala. Water and Sewage Assn.	20
Arkansas	1940	Ark. Water and Sewage Assn.	36
California	1936	Calif. Section, AWWA	50
Florida	1941	Fla. Water and Sewage Works Assn. and Fla. Dept. of Health	16
Georgia	1936	Ga. Water and Sewage Assn.	35
Illinois	1938	Ill. Dept. of Health	50
Kentucky	1940	Ky. Dept. of Health	
Louisiana	1940	La. Conference on Water Supply and Sewage	
Minnesota	1951	Minn. Dept. of Health	10
Missouri	1941	Mo. Water and Sewerage Conference	20
North Carolina	1940	N.C. Dept. of Health N.C. Water Works Operators Assn.	85
North Dakota	1937	N.D. Water and Sewage Works Conference	15
Oklahoma	1949	Okla. Water, Sewage, and Industrial Wastes Conference and Okla. Dept. of Health	30
Pennsylvania	1951	Pa. Water Works Operators Assn.	
South Carolina	1935	S.C. Water and Sewage Works Assn. and S.C. Board of Health	
Tennessee	1939	Tenn. Dept. of Health	60
Mandatory Certification (State Statute)			
Connecticut	1933	Conn. Dept. of Health	100
Michigan	1941	Mich. Dept. of Health	95
New Jersey	1918	N.J. Dept. of Health	99
New York	1937	N.Y. Dept. of Health	100*
Ohio	1937	Ohio Dept. of Health	100
Texas	1945	Tex. Dept. of Health	80
West Virginia	1933	W.Va. Dept. of Health	90

* May vary slightly owing to administrative operations.

percentage of certified operators under the voluntary system.

This comparison reveals a weakness inherent in the voluntary system. The tendency under such a system is to certify the competent and progressive operators only. Because the plan is voluntary, the unqualified and uninterested operators have little incentive to try to become certified. Many of these operators are located in small towns. Thus, the voluntary certification plan fails where it is needed most. This basic concept should be thoroughly understood by those administering a voluntary program. In fact, it should be considered only a stepping stone to a mandatory system.

Mandatory programs also experience their greatest difficulties in certifying the small water system operators, largely owing to the lack of qualified personnel in small towns. Consequently, the program of certification must also provide for educational facilities such as short courses to help operators qualify. Educational programs are time consuming and difficult to develop to meet the varied needs of the operators. Nevertheless, such programs are profitable if followed through to completion.

Of the voluntary systems of certification now being practiced in 16 states, 7 are administered by the local (state) water works association, 1 by the state AWWA section, 4 by state health departments, and the remaining 4 by a combination of state health departments and local water works associations. An analysis of the percentage of eligible operators certified under each of these four administrative categories shows that a voluntary certification plan operated solely by the state health department, or by the state health department in conjunction with the local water works association, produces results (48 per cent of operators certified) superior to those produced when certification is administered solely by the local water works association (26 per cent certified). The certification plan in California is administered by the AWWA section, which has done a commendable job, 50 per cent of the eligible operators being certified. Generally, however, if voluntary certification is adopted, it appears advisable to have the state health department administer the program or share in its administration. All mandatory certification programs are administered by state health departments.

Certificate Grades

The survey indicates that a wide variety of classes or grades of certificates is being used. One state has seven grades, although three or four is the most common number—8 and 9 states, respectively. Three states have five grades; 1 state, one grade; and 1 state, six grades. It is also of interest that in 10 states the operators and managers of both treatment plants and distribution systems are certified, while in 13 states only treatment plant operators are certified.

Candidate Requirements

A review of the list of requirements for candidates for certification (appended to this report) will provide a key to the scope of the programs. Educational, experience, and character requirements are included.

Tenure of Certificate

An analysis of the policies of the 23 certification programs on certificate tenure shows that 6 states issue certificates good indefinitely unless re-

voked for cause. In contrast, 2 states issue certificates that expire after 1 year; 5, after 2 years; 4, after 3 years; and 4, after 5 years. Two states issue certificates for different lengths of time, depending on the class; that is, Class C certificates for 3 years; Class B, for 5 years; and Class A, permanent. One state permits certificates of limited tenure to become permanent when the candidate has passed three examinations taken at 2-year intervals.

Renewal of certificates on expiration is accomplished in a number of ways: by examination, by application and payment of a fee, by attendance at a state water conference, by completion of two out of three short courses, by application and examination or attendance at school, and by discretion of an examining board.

Reciprocity

Nineteen of the states that have a certification program do not honor the certificates of other states. The chief reason for this lack of reciprocity apparently is the absence of a need or demand for it. Four states—Arkansas, Florida, Ohio, and Texas—have actually practiced reciprocity on a very limited scale, Texas having accomplished more than any of the other states. It is of interest that 14 of the states with certification programs indicate a belief that reciprocity is desirable, while 5 think not and 4 remain neutral.

It appears that reciprocity can never be established on a nationwide basis until the disparity in the quality of certification between the states is at least partially eliminated. Within certain limitations, reciprocity might now be established between those states that have mandatory certification. Their qualification standards for candidates are not very far apart. The fact remains, however, that, even though the majority opinion is favorable to such a scheme, there is at present no great need for it. A war or other emergency could alter that position.

Examinations

Practically all the states—22—require candidates to pass examinations to obtain a certificate of competency. Illinois uses only training and experience records to establish qualification for certification. In one state, the examination is usually oral, while, in another, it may be either written or oral. The great majority require the passing of written examinations to qualify for a certificate. Michigan also requires the candidate to pass a practical laboratory test in the techniques of conducting chemical and bacteriological water examinations.

Revocation of Certificates

Provision is made in most certification programs for the revocation of certificates for cause, such as incompetence, practice of fraud or deceit, or negligence. Sixteen states reported such provisions, while five indicated that they had none.

Evaluation of Certification

An effort has been made to evaluate the benefits resulting from certification programs in the 23 states that have them. Table 6 shows quite conclusively that, in the opinion of the people who answered the questionnaires, certification programs are very much worth while. The summary further indicates that the greatest benefits are received from those certification programs that are supported by a state statute.

There is general agreement that certification programs have benefited the public health and raised the quality and morale of the operators. These are creditable accomplishments. If "don't know" is accepted as negative, however, it will be seen that opinion was almost evenly divided on the effect certification has on the financial status of the operators and on the removal of their jobs from politics.

The value of mandatory certification was indicated by the unanimity of opinion, in states that have it, on the benefits obtained. For example, there was no question that compulsory certification enhanced the public health, raised the quality of the operators, and removed their jobs from politics. The opinion was also practically unanimous that compulsory certification, by assuring job security, raised the morale of the operators. Even in the matter of improving the financial status of the operators, the opinion was in the affirmative, although not unanimously so. In contrast, a review of the opinions expressed in the sixteen states with voluntary certification plans indicated that there was no certainty of improving the financial status of the operators or of removing their jobs from politics. These conclusions would still hold even ignoring the replies from the three states (Alabama, Minnesota, and Pennsylvania) that have not practiced voluntary certification long enough to develop an accurate opinion.

TABLE 6

Opinions on Effects of Certification

Effect	States With Voluntary Certification				States With Mandatory Certification			
	Yes	Weak Yes	No	Don't Know	Yes	Weak Yes	No	Don't Know
Enhanced public health	12		1	3	7			
Raised quality of operators	11		1	4	7			
Raised morale of operators	10	1		5	6			1
Improved financial status of operators	4	1	3	8	4	2		1
Removed jobs from politics	4	1	4	7	7			

College-trained Operators

This overall improvement in the quality of water plant operators is due in large measure to the impetus provided by certification programs which showed up educational deficiencies and produced a remedy in the development of present extensive in-service courses. These are carried on under the auspices of health departments, AWWA sections, state conferences, colleges, and similar groups. The in-service training courses have given considerable help to the small plant operator in passing qualifying examinations to become certified, and for that accomplishment health departments can be genuinely thankful. Unfortunately, certification has not attracted college-trained men.

A special letter was written to eight states, four practicing compulsory certification and four voluntary certification, to learn something about their records on college-trained certified operators. The four states practicing

compulsory certification were Michigan, Ohio, Texas, and West Virginia; the voluntary-plan states, Arkansas, California, Georgia, and Missouri. These states were asked to compare the percentage of the highest class of certified operators holding college degrees at present with the percentage in the first full year of operation under the certification plan. The replies from three of the states practicing mandatory certification (Ohio data were unavailable) are summarized in Table 7. The experiences of the three mandatory-certification states were surprisingly similar. All three showed a decline of 1 per cent in the number of certified operators holding college degrees over a period ranging from 5 to 18 years. The results clearly indicate that compulsory certification programs do not attract college-trained personnel. By the same token, such programs do not deter college men from continuing in this field of endeavor.

TABLE 7

Operators With College Degrees (Mandatory-Certification States)

State*	Class of Certification	First Year			Last Year			Per Cent Improvement
		Year	Operators		Year	Operators		
			No.	%		No.	%	
Michigan	F1	1941	24	67	1951	35	66	−1
Texas	A	1945	24	32	1950	41	31	−1
West Virginia	1st	1934	22	56	1952	20	55	−1

* Ohio data unavailable.

The level of employment of college graduates as certified water plant operators apparently varies considerably between the states. Michigan shows a college-trained operator employment level of 66 per cent, slightly more than twice the Texas level. West Virginia presents a very creditable showing of 55 per cent of the operators in the highest certification category. If the Michigan record is carried back to 1937, when certification was under department regulation, the percentage is found to be 67 (the same as in 1941), a further indication of the stability of this ratio.

The source of the West Virginia statistics stated that:

> It is apparent . . . that our certification program has not been instrumental in attracting better educated men into the field. In my opinion, we have a better educated and qualified group of second-class operators today than we had 20 years ago, but that is due to the higher educational level which prevails generally. It is my frank opinion that our certification program has not materially improved the economic status of the water plant operator and such positions today are less attractive to the competent man than they were 20 years ago.

The replies from the four selected states practicing voluntary certification were not encouraging. Arkansas reported that 52 per cent of the Class A certificates in 1941 were held by college-trained operators. By 1951 a 9 per cent loss had brought this figure down to 43 per cent. In contrast, in Georgia, the percentage of college-trained certified personnel rose from 50 to 75 per cent during the period

1941–51. The source of the Georgia statistics pointed out, however, that they do not tell the whole story:

> Actually between 1941 and 1951 the number of men holding Class A certificates had decreased approximately two-thirds. Most of these left to accept positions with defense plants, the military service, or private industry, but I am certain the fact that they held A certificates helped several to get better positions.

California reported that:

> During the year 1941 our certification committee was inactive and no certificates were issued; 1943 is the closest year in which any number of certificates were issued. During 1943 thirteen certificates were issued, and four (30.7 per cent) of those certified had some college training. During 1951 a total of 61 certificates was issued, and seventeen (28 per cent) of the men certified had some college training.

The situation in Missouri was summed up thus:

> The voluntary licensing program of the Missouri Water and Sewerage Conference was started in 1941. Operators were first issued licenses on Apr. 12, 1941. From that date to 1951 eight operators received Class A license certificates. Six of the eight have college degrees. The two having passed the Grade A examinations without college degrees have taken correspondence courses and have been in water works operation for many years. Approximately ten or twelve others during the past 10 years have tried for the Grade A license but have failed.
>
> In my opinion, certification of water works operators has had little or nothing to do with attracting college-trained men to the water works profession.

Summary

1. Certification programs are growing in number in the United States. During the past 17 years (1935–52) they have increased from five to 23. The chronological distribution of these programs shows New Jersey as the leader in 1918. There followed a period of 12 "fruitless" years, broken by Michigan in 1931. One to four states followed Michigan's lead during each of the next 8 years, during which period (1931–41) eighteen states inaugurated certification programs. No new programs were started during and immediately after World War II (1942–48). In 1949 Oklahoma launched a program, followed by Alabama in 1950 and Minnesota and Pennsylvania in 1951. No additions were made in 1952.

2. The majority of the certification programs are of the voluntary type. Sixteen of the 23 programs fall into this category.

3. Compulsory certification programs are superior to voluntary programs when analyzed according to these criteria: [1] number of eligible operators certified; [2] safeguarding the public health; [3] raising the quality of the operators; [4] raising the morale of the operators; [5] improving the operators' financial status; and [6] removing the jobs from politics.

4. Reciprocity among the states practicing certification appears to be desirable in the opinion of the majority; however, the need for reciprocity is not established.

5. Twenty-two of the 23 states practicing certification programs require the successful completion of an examination to become certified.

6. Revocation of certificates for cause is firmly established but so far has not been practiced.

7. Certification programs do not attract college graduates to the water works field. Economic conditions apparently control such decisions.

Recommendations and Conclusions

Based upon its studies, the committee recommends that:

1. Short courses with higher educational prerequisites should be developed for water works personnel; however, more emphasis should be placed on in-service training, extension, and correspondence courses.

2. Conferences for management should be developed.

3. With the general availability of extension and correspondence courses throughout the United States, offering formal training either in engineering or in science subjects of benefit to water works personnel, the future program of the Association should encourage study in such courses.

4. Where certification is instituted, it should be of a compulsory type administered by the state department of health. Voluntary certification programs should aim toward a compulsory program as a final objective.

5. Certification should be permanent unless revoked for cause.

6. Candidates for certification should be required to pass an examination, preferably written.

7. Certificate classifications should be uniform.

8. There should be uniformity in examinations for certification in equal grades or classes.

The adoption of such a program by the Association should result in the following benefits:

1. The assurance that technically trained personnel will be in responsible charge of all public and private water supply systems.

2. Substantially higher educational qualifications for water plant operators.

3. Certifying of water works operators.

4. Adequate salaries and tenure.

APPENDIX

Requirements for Certification

On the following pages are tabulated the requirements for certification in the 23 states that have either voluntary or mandatory plans.

APPENDIX—*Requirements for Certification*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—yr	Character*	
Ala.	1	manager or superintendent of system	*a.* high school *b.* high school plus training in water chemistry and bacteriology *c.* 2 yr college plus training in chemistry and bacteriology *d.* college (B.S.)	*a.* 10 *b.* 8 *c.* 6 *d.* 4	√	none
	2	superintendent or chief operator of filter plant	*a.* high school *b.* high school plus training in chemistry and bacteriology *c.* 2 yr college plus training in chemistry and bacteriology *d.* college (B.S.)	*a.* 6 *b.* 4 *c.* 2 *d.* 1	√	written
	3	filter plant operator	grade school	1	√	written
	4	operator of plant without treatment			√	none
Ark.†	A	chief operator of filter or softening plant serving over 10,000 population, or of ground water supply system serving over 25,000	*a.* high school or less *b.* 2 yr college *c.* college	*a.* 5–10 *b.* 5 *c.* 1–2		written
	B	filter or softening plant serving less than 10,000 population or ground water supply system serving 5,000–25,000	*a.* high school plus training in chemistry and bacteriology *b.* none	*a.* 2 *b.* 5	√	written
	C	operators of all other supplies; also subordinates of men with higher classifications	none	2	√	written
Calif.	1	chief operator of complete treatment plant; superintendent of complex system	*a.* high school plus 10-wk training course *b.* college (B.S.)	*a.* 10 *b.* 2	√	written and oral
	2	operator of complete treatment plant; superintendent of smaller system	*a.* high school plus 10-wk training course *b.* high school	*a.* 2 *b.* 3	√	written; also oral if written grade 60–70
	3	operator of simple system; subordinate in complete treatment plant	*a.* 10-wk training course *b.* none	*a.* 1 *b.* 2	√	written; also oral if written grade 60–70
	4	operator in training	none	none	√	none
Conn.	no grades	all treatment plant operators	must show evidence of ability to read and interpret instructions and keep necessary records	‡		usually oral

* Check mark indicates that character is considered.
† Candidate must be member of state water and sewage conference and attend meetings.
‡ No period specified; must be qualified by experience to operate disinfection or filter plant.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—*yr*	Character*	
Fla.	A	all types of treatment; fundamentals of plant design; maintenance, etc.	*a.* high school or equivalent *b.* high school or equivalent plus training in bacteriology and chemistry *c.* 2 yr college plus training in bacteriology and chemistry *d.* college (B.S.) *e.* college (B.S.) plus 1 yr short school *f.* 1 yr short school *g.* 2 yr short school *h.* 3 yr short school	*a.* 10 *b.* 8 *c.* 6 *d.* 4 *e.* 3 *f.* 8 *g.* 7 *h.* 6		written
	B	all types of treatment; fundamentals of plant design; maintenance, etc.	*a.* high school or equivalent *b.* high school or equivalent plus training in bacteriology and chemistry *c.* 2 yr college plus training in bacteriology and chemistry *d.* college (B.S.) *e.* college (B.S.) plus 1 yr short school *f.* 1 yr short school *g.* 2 yr short school *h.* 3 yr short school	*a.* 6 *b.* 4 *c.* 2 *d.* 1 *e.* 1 *f.* 4 *g.* 3 *h.* 2		written
	C	treatment, especially plant control tests; also knowledge of plant equipment	grade school or equivalent	§		written
	D	disinfection or pumping	none	§		varies
Ga.†	A	not classified; regularly employed in water plant	*a.* 1 yr short course *b.* 2 yr short course *c.* 3 yr short course *d.* college (B.S. and 1 yr short course)	*a.* 8 *b.* 6 *c.* 4 *d.* 3		written
	B	not classified; regularly employed in water plant	*a.* 1 yr short course *b.* 2 yr short course *c.* 3 yr short course *d.* college (B.S. and 1 yr short course)	*a.* 4 *b.* 3 *c.* 2 *d.* 1		written
	C	regular employee in water plant	none	none		written

* Check mark indicates that character is considered.
† Candidate must be member of state water and sewage conference and attend meetings.
§ Knowledge of chlorination and control is required.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—*yr*	Character*	
Ill.	AA	operation and supervision of treatment plant; make control tests; understand maintenance and operation of equipment	college (B.S.) or equivalent	6, including 4 in charge of operation		none
	A	operation and supervision of treatment plant; make control tests; understand maintenance and operation of equipment	high school or equivalent	5, including 2 in charge of operation		none
	B	operation of treatment plant; knowledge of control tests and of plant maintenance	grade school or equivalent	3		none
	C	operator in treatment plant; knowledge of control tests	grade school or equivalent	1		none
Ky.	1	in charge of complete treatment plant serving over 25,000 population	education plus experience count 10–40% toward final grade, weight increasing for higher classifications; exam counts 60–90%, weight decreasing for higher classifications; experience credit earned at rate of 2% per year of actual operation; education credit for college degree (A.B. or B.S.) is 10–20%			
	1‖	in charge of complete treatment plant serving 5,000–25,000				
	2	in charge of complete treatment plant serving less than 5,000				
	2a‖	in charge of complete treatment plant serving less than 5,000				
	2b‖	disinfection only; population served, 5,000–100,000				
	3‖	disinfection only; population served, less than 5,000				
La.	1	operator of complete treatment plant, serving 25,000 or more; disinfection only, serving 100,000 or more	*a.* college (B.S.) *b.* college (A.B.) *c.* 2 yr college *d.* high school or less	*a.* 1–2 *b.* 3 *c.* 5 *d.* 5–10		written
	2	complete treatment, population under 25,000	high school or equivalent, with training in chemistry and bacteriology	2		written
	3	disinfection only; subordinate positions	none			written

* Check mark indicates that character is considered.
‖ Restricted to specific plant.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—*yr*	Character*	
Mich.#	F1	filtration or softening plant (5 mgd or larger) serving 40,000 or more	college (A.B. or B.S.) or equivalent	5–12	√	written
	F2	filtration or softening plant (1–5 mgd) serving 4,000–40,000	some college	2–30	√	written
	F3	filtration or softening plant (under 1 mgd) serving less than 4,000	high school or equivalent	1–30	√	written
	D1	disinfection plant (1 mgd or larger) serving 4,000 or more	high school or equivalent	1–2	√	written
	D2	disinfection plant (under 1 mgd) serving less than 4,000	grade school	1–2	√	written
	M	iron removal, softening, corrosion control, fluoridation, etc.	grade school	½–6	√	written
	T	bacterial control of disinfection plants	high school	½–12	√	written
Minn.**	A	complete treatment of surface supply (coliform index 250–20,000 MPN) serving 30,000 or more	*a.* high school plus training in chemistry and bacteriology *b.* college (B.S.)	*a.* 7 *b.* 3	√	written
	B	complete treatment of surface or ground supply (coliform index 0–250 MPN) serving 10,000–30,000	*a.* high school plus training in chemistry and bacteriology *b.* college (B.S.)	*a.* 5 *b.* 2	√	written
	C	treatment (disinfection, fluoridation, iron removal, softening, etc.) of ground water supply (coliform index usually 0) serving 5,000–10,000	high school	3	√	written
	D	treatment (stabilization with phosphate) of ground water supply (coliform index usually 0) serving less than 5,000	grade school	2	√	written

* Check mark indicates that character is considered.
\# Point system employed to weight candidate qualifications and examination score.
** Candidate must be physically fit.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—yr	Character*	
Mo.†	A	complete treatment (14 processes listed); must be familiar with operation and maintenance of plant equipment, hydraulics, sanitation	*a.* college (B.S.) *b.* completion of 4 Univ. of Missouri correspondence courses	*a.* 2–3 *b.* 5		written, oral, laboratory
	B	complete treatment (8 of 14 processes listed for Grade A)	*a.* college (B.S.) *b.* completion of 4 Univ. of Missouri correspondence courses	*a.* 1–2 *b.* 5		written
	C	treatment (6 of 14 processes listed for Grade A)	*a.* college (B.S.) *b.* completion of 4 Univ. of Missouri correspondence courses	*a.* 0–1 *b.* 3		written
	D	treatment (3 of 14 processes listed for Grade A)	*a.* college (B.S.) *b.* completion of 4 Univ. of Missouri correspondence courses	*a.* none *b.* 1		written
N.J.	1	5-mgd or larger filtration plants (coagulation, settling, disinfection); and all other 10-mgd or larger treatment plants	*a.* 1 yr college or equivalent *b.* 2 yr college or equivalent *c.* 3 yr college or equivalent *d.* college (B.S.) or N.J. professional engineer license	*a.* 5 *b.* 4 *c.* 3 *d.* 2		written
	2	less than 5-mgd filtration plants (coagulation, settling, disinfection); and all other 5–10-mgd treatment plants	*a.* 1 yr training *b.* 2 yr training *c.* college (B.S.) or N.J. professional engineer license	*a.* 4 *b.* 3 *c.* 1		written
	3	1–5-mgd treatment plants	*a.* 1 yr training *b.* 2 yr training	*a.* 2 *b.* 1		written
	4	less than 1-mgd treatment plants not covered in other grades	1 yr training	1		written
	5	less than 25,000-gpd disinfection plants serving public schools				written

* Check mark indicates that character is considered.
† Candidate must be member of state water and sewage conference and attend meetings.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—yr	Character*	
N.Y.	1	treatment plant serving 20,000 or more; or filtration plant serving 10,000 or more	*a.* college (B.S.) *b.* completion of course of instruction in treatment *c.* high school (special cases)	*a.* 1 *b.* 5 *c.* 5	√	written, oral, or practical (as required by public health council)
	2	treatment plant serving 5,000–20,000; filtration plant serving less than 10,000; or subordinate operator in Grade 1 plant	*a.* high school plus course in water treatment *b.* completion of course in water treatment†† *c.* not specified (special cases)††	*a.* 1 *b.* 3 *c.* 2	√	written, oral, or practical (as required by public health council)
	3	treatment plant (other than filtration) serving less than 5,000; or subordinate operator in Grade 2 plant	*a.* not specified†† *b.* completion of course in water treatment††	*a.* 1 *b.* ½	√	written, oral, or practical (as required by public health council)
N.C.	A	all types of treatment; operation; records	*a.* high school plus training in bacteriology and chemistry *b.* 2 yr college plus training in bacteriology and chemistry *c.* college (B.S.)	*a.* 6 *b.* 4 *c.* 2–3		written
	B	all types of treatment but not to same degree as for Grade A	*a.* high school *b.* high school plus training in bacteriology and chemistry *c.* 2 yr college plus training in bacteriology and chemistry *d.* college (B.S.)	*a.* 6 *b.* 4 *c.* 2 *d.* 1		written
	C	routine bacteriological and chemical tests; record keeping; coagulation and disinfection	*a.* 1 yr training school *b.* high school *c.* high school plus training in bacteriology and chemistry *d.* college (B.S.)	*a.* 2 *b.* 1 *c.* ½ *d.* none		written
	C	operation of plants using wells and unfiltered surface supplies	*a.* 1 yr training school *b.* grade school *c.* high school *d.* college	*a.* 2 *b.* 1 *c.* ½ *d.* none		written

* Check mark indicates that character is considered.
†† Ability to read, write, and do simple arithmetic is required of candidates for all grades.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—yr	Character*	
N.D.	1	superintendent or chief operator of treatment plant involving chemical and bacteriological laboratory control	*a.* college (B.S.) *b* college (A.B.) plus course in chemistry *c.* 2 yr college *d.* high school or less	*a.* 1–2 *b.* 3 *c.* 5 *d.* 5–10		none
	2	operator of complete treatment plant	high school plus training in bacteriology and chemistry or pass comprehensive exam	2 (in Grade 1 or 2 plants)		
	3	subordinate position in higher-grade plants; operator of aeration, corrosion control, or disinfection equipment; or operator of system where no treatment is used	pass comprehensive exam	1		
Ohio**	A	in responsible charge of treatment plant	*a.* has Grade B certificate *b.* college *c.* registration as professional engineer in Ohio *d.* college (B.S. in engineering or specialized training in sanitary engineering)	*a.* 1 *b.* 3 *c.* 2 *d.* 2	√	written
	B	treatment plant serving less than 30,000	*a.* college *b.* high school *c.* college (B.S. in engineering or specialized training in sanitary engineering)	*a.* 2 *b.* 4 *c.* 1	√	written
	C	disinfection of well water supply	*a.* college *b.* high school *c.* grade school	*a.* ½ *b.* 1 *c.* 2‡‡	√	written
Okla.†,**	A	filtration and softening plants serving 20,000 or more	*a.* college (B.S.) *b.* college (B.S. and M.S.) *c.* less than above but not specified††	*a.* 6 *b.* 5 *c.* 8		written and oral
	B	filtration and softening plants serving up to 20,000; or well water systems serving 10,000 or more	*a.* college (B.S.) *b.* less than above but not specified††	*a.* 1 *b.* 3		written and oral
	C	well water systems serving up to 10,000; all other plants not covered in higher grades	*a.* college (B.S.) *b.* less than above but not specified††	*a.* none *b.* 1		written

* Check mark indicates that character is considered.
† Candidate must be member of state water and sewage conference and attend meetings.
** Candidate must be physically fit.
†† Ability to read, write, and do simple arithmetic is required of candidates for all grades.
‡‡ Six months' experience credit given for completion of short course.

APPENDIX—*Requirements for Certification (contd.)*

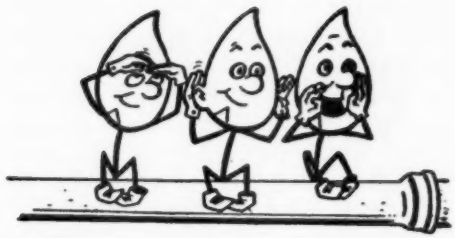
State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—*yr*	Character*	
Pa.	A	complete treatment plant serving 25,000 or more; any plant serving 50,000 or more	*a.* college (B.S.) *b.* college (B.S.) plus postgraduate work *c.* high school *d.* high school plus 4 short courses	*a.* 2 (in Grade A or B plants) *b.* 1 *c.* 10 *d.* 8½		written or oral
	B	complete treatment plant serving 10,000–25,000; any plant serving 20,000–50,000	*a.* college (B.S.) *b.* high school plus short courses	*a.* 1–5 *b.* 6–10		written or oral
	C	complete treatment plant serving 5,000–10,000; any plant serving 10,000–20,000	*a.* high school plus short courses *b.* read and write	*a.* 3 *b.* 10		written or oral
	D	plants not covered above	read and write plus short course	2		written or oral
S.C.§§	A	all types of treatment plants	4 short courses	5	√	written
	B	all types of treatment plants	3 short courses	4	√	written
	C		2 short courses	2	√	written
	D		1 short course			written
Tenn.	A	complete treatment plant serving 15,000 or more	*a.* college (B.S.) *b.* high school plus training in bacteriology and chemistry (each year of college equivalent to 2 yr experience)	*a.* 1 *b.* 9		written
	B	complete treatment plant serving 2,000–15,000; or disinfection plant serving 15,000 or more	*a.* high school plus training in bacteriology and chemistry *b.* grade school plus training in bacteriology and chemistry (each year of high school equivalent to 1½ yr experience)	*a.* 1 *b.* 7		written
	C	complete treatment plant serving less than 2,000; disinfection plant serving less than 15,000; or any plant with no treatment serving 15,000 or more	*a.* grade school *b.* read and write	*a.* 1 *b.* 4		written
	D	plant with no treatment serving less than 15,000	read and write	1		written

* Check mark indicates that character is considered.
§§ Candidate for Grade A certificate must submit thesis on appropriate subject; candidate for Grade B certificate must hold lower-grade certificate.

APPENDIX—*Requirements for Certification (contd.)*

State	Certificate Grade	Plant or Job Description	Candidate Requirements			Examination
			Education	Experience—yr	Character*	
Tex.	A	administration, production, distribution, or control	*a.* college (B.S. and M.S.) *b.* college (B.S.) *c.* short course (6 standard schools or 120 hr)	*a.* 5 *b.* 6 *c.* 8		written
	B	administration, production, distribution, or control	*a.* college (B.S.) *b.* short courses (2–4 standard schools or 40–80 hr)	*a.* 1 *b.* 3		written
	C	administration, production, distribution, or control	*a.* 2 short courses or 40 hr *b.* 1 short course or 20 hr *c.* none	*a.* 1 *b.* 2 *c.* 3		written
W.Va.	1	in charge of complete treatment plant serving 25,000 or more	college (A.B. or B.S.)	3–8½		written
	1‖	in charge of complete treatment plant serving 5,000–25,000	college (A.B. or B.S.)	3–8½		written
	2	complete treatment plant serving less than 5,000	not specified	1		written or oral
	2‖	complete treatment plant serving less than 5,000; or disinfection plant serving 5,000 or more	not specified	1		written or oral
	3‖	disinfection plant	not specified	¼		written or oral

* Check mark indicates that character is considered.
‖ Restricted to specific plant.



Percolation and Runoff

All animality's water works and worries appear to have enjoyed the same kind of increase in public attention and sympathy that has been directed to the merely human problems in the field. Thus, within the past month, our files have been almost overrun by everything from rats to hippopotami.

Among the first arrivals was a lone wild beaver, who, taking a fancy to a ten-acre private lake on a large estate in Long Ridge, Conn., conducted a running riparian battle with the owners to make it bigger—dam after dam after damn dam. Next, out near Delaware, Ohio, a slightly less amphibious shorthorn, weighing 1,100 lb, apparently became so desperate for a drink that she plunged right into a 7-ft well and had to be floated out on water firehosed in. And at Mt. Clemens, Mich., a parched pooch went to similar extremes when he clambered up a bird bath for a drink but got a bath instead, as base, pedestal, tray, silver ball, and he, all ended up in a humid heap. At Cleveland, meanwhile, a chicken, who had hatched a brood of nine ducklings, made a pathetic splash in the headlines by wading in after her kiddies and trying to keep them somehow moored to her apron strings. And at Louisville, Ky., a flock of 40 ducks have made their home on the air-conditioning water pool atop the Sears Roebuck store—welcome, too, for their contributions to algae control.

Re those rats and hippopotami, though, we are, we must admit, a little less enthusiastic. For instance, we've just learned that the desert rat can get along—even in all the heat and aridity of Death Valley—"on dry food and no water at all," despite the fact that its body has about the same water content (65 per cent) as that of other [more cooperative] animals. Secret of this accomplishment [which we hope it will keep] lies in its ability to make its own water internally in the oxidation of its food. And once made, the water is almost unbelievably conserved by a most efficient kidney and by the kidney keeper's avoidance of the rigors of daytime exposure. Since that kidney is good enough to permit the beast even to drink salt water to maintain its water balance, it should be quite obvious why it has no use for us—and vice, believe us, versa! Bigger, of course, has been the hippopotamusical problem faced by the water supply authorities of Mombasa, East Africa, who have thus far been unable to use their best source of supply on Mzima Springs,

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because it is the "ancestral pool" of the local hippopotami. All efforts to evict them have been met by public protest, supporting the case of "the monstrous beasts dancing their eternal ballet down in the clear depths of that beautiful pool attended by their clouds of fishlike blue butterflies."

Inasmuch as the combination of butterflies and kidney action has reminded us of something all too human, we'll take leave of our essays in zoohydrology forthwith with a noncommital report that Washington, D.C., has 75 horsetroughs, New York has 37, and Detroit, the motor city, 24.

Corrosion curricula will soon appear at three universities, thus raising rustication to honorable status. At A&M College of Texas, College Station, a corrosion short course will be held Sept. 22–25. At the Univ. of Oklahoma, a Corrosion Conference will be held Dec. 1–4. Finally, at the Univ. of Illinois, Urbana, short courses in cathodic protection will be given Oct. 12–16, and will include lectures, field trips, and laboratory demonstrations. All three activities are being cosponsored by the National Assn. of Corrosion Engineers or its local sections.

Correspondence courses for water and sewage plant operators are being inaugurated by the General Extension Div. of the Univ. of Florida's College of Engineering. The first course, "Basic Mathematics for Water and Sewage Plant Operators" is now ready for students, who should communicate with the General Extension Div., Univ. of Florida, Gainesville, Fla., for information. Additional courses are being prepared on Basic Science, Plant Operation and Control, and Equipment Operation and Maintenance.

A symposium on solar energy utilization, other than agricultural, is to be held at the University of Wisconsin Sept. 12–14 and will include discussion of sea water evaporation; solar heating for houses, water, and cooking; and other matters.

Splashings are what "you're bound to get if your work involves water or sewage" in Kansas—or anywhere else for that matter, but then it would be splashings rather than *Splashings,* for the latter is the new mimeographed news-letter prepared and distributed by the Kansas State Board of Health to all water works and sewage works men in the state. In greeting Issue No. 1, July 1953, we owe a bow, too, not only to similar publications in other states, but to the state departments of health generally for keeping water works men, locally, interested, acquainted, and informed. Bob Millar, AWWA Kansas Section Chairman, is credited with siring the new quarterly and Herman Janzen, sanitary engineer with the board, appears to have been either mother or midwife. Meanwhile, at first splash, the infant seems to have gotten something on almost everybody in Kansas.

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(*Continued from page 34 P&R*)

U.S. Pipe & Foundry Co. has moved its general offices from Burlington, N.J., to Birmingham, Ala., at 3300—1st Ave., N. Remaining in the former General Office Bldg. at Burlington are the Special Products Div., the Research & Development Dept., the Quality Control Dept., and the Export Sales Office, as well as the Eastern Sales, Traffic, and Purchasing Offices. The Philadelphia Sales office, meanwhile, has been consolidated with the Eastern Sales Office at Burlington.

At the new building, the Sloss-Sheffield Steel & Iron Div. has been consolidated with the parent company and will no longer function separately. The company announced that the relocation of the General Offices to its major producing area is expected to result in better efficiency of operation.

Wade Plummer, vice-president and general manager of the Butte, Mont., Water Co., was stricken and died suddenly on July 12. He was 61 and had not seemed to be in ill health. A Fuller Award winner and active in Association affairs, Plummer had been connected with the Butte Water Co. since 1919, when he returned from overseas service with the Marine Corps.

W. A. Bandy, chief water works instructor for the Texas Engineering Extension Service of Texas A&M College, died on June 3 at El Paso, after suffering a heart attack. He was 66. Over 1,000 water works men in Texas are said to owe their operator's licenses to his activities in teaching and course administration.

(*Continued on page 38 P&R*)

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Tradition and Technology in England

H. F. Cronin (left), chief engineer of London's Metropolitan Water Board, points out some interesting features of the three-century-old "New" River to Ross Dobbin, who had come to England to witness the Coronation. Although the New River's course has been shortened and the original springs it conveyed to London are no longer a reliable source of supply, it still brings 40 mgd (Imp.) of Lee River water to the Board's Stoke Newington Works. The channel had been constructed by Sir Hugh Myddelton to bring water from springs in Hertfordshire to London, and was originally 40 miles long. Completed in 1613, it had taken 10 years to build.

Ross Dobbin's presence at the Queen's coronation marks a gain in prestige and official recognition of engineering (which he represented in his position of president of the Engineering Institute of Canada), as this is the first time that engineers were included among the "learned professions" recognized by royal protocol. The reverse side of the coin is represented by the awarding of honorary membership in the Engineering Institute of Canada to the Duke of Edinburgh, in recognition of the very great interest shown by His Royal Highness in science and engineering.

Canadian wet water is at last on a par with Canada Dry water, having finally earned the rating of "goods" in the latest amendment of the Excise Tax Act. What this means is that water works chemicals can now be obtained by municipal water works plants without payment of sales tax, upon certification that they "are to be consumed or expended directly in the process of manufacture or production of goods." No goods yet—or again—are the effluents of sewage treatment plants; thus for sewage treatment chemicals the sales tax must be paid. For a superintendent of both goods and bads, that could get complicated.

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The great upbubblements that plagued sewage treatment plants when synthetic detergents were first used in quantity would have been as nothing compared with that at New Hartford, Conn., last month if the trailer truck that crashed through a retaining wall there had rolled just a few more feet to deposit its 800 cases of beer in the city reservoir. New Hartford could certainly have claimed the only distribution system in which there was gain of head; even without soap the water would have been good and sudsy; and the water company could undoubtedly have billed the brewer regular space rates for the advertising thereby distributed. Only worry would have been an adulteration charge by the Food and Drug Administration which frowns on the cutting of products sold by weight or volume to the extent that a restaurateur was recently fined $25 for watering his coffee. Of course, that happened in Germany; and, of course, the Superior Court at Karlsruhe lifted the fine on appeal; and, of course, the beer didn't quite reach the reservoir anyway. But there'll come a day!

Moore F. Floyd has been appointed sales representative in the Texas area for Reilly Tar & Chemical Co., replacing Charles L. Slover. He will be stationed at Dallas, Tex.

A. H. Honeck has been appointed district manager in Ohio and northern Kentucky for Graver Water Conditioning Co., and will maintain offices at 1103 Citizens Bldg., Cleveland, and 3427 Corrine Ave., Cincinnati.

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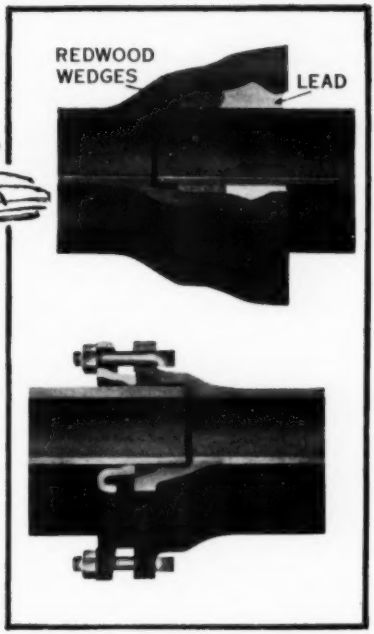
TAKE YOUR CHOICE



TRENCH POURED

BELL & SPIGOT

Or

PRECALKED

Or BOLTITE

Select any of these three types of joint when you order McWane-Pacific Super-DeLavaud Cast Iron Pipe, 18-foot laying lengths. All three types of joint are tried and tested through years of service.

The two joints illustrated above (Precalked and Boltite) are available in all sizes of McWane-Pacific Super DeLavaud pipe. Precalked Joint has all of the joint materials (lifelong redwood wedges and pure virgin lead) placed in the bell at our foundries. All you do is "socket and calk it."

Boltite is a bolted, flexible joint, designed on the stuffing box principle. The thick gasket is compressed by the bolted gland until the joint is bottle-tight.

McWane-Pacific pipe also is available in 2-inch and 2¼-inch diameters, 18-foot laying lengths. Write or wire—

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Salt Lake City	Waterworks Equip't Co.
Seattle, Wash.	1806 Smith Tower Bldg.

(Continued from page 40 P&R)

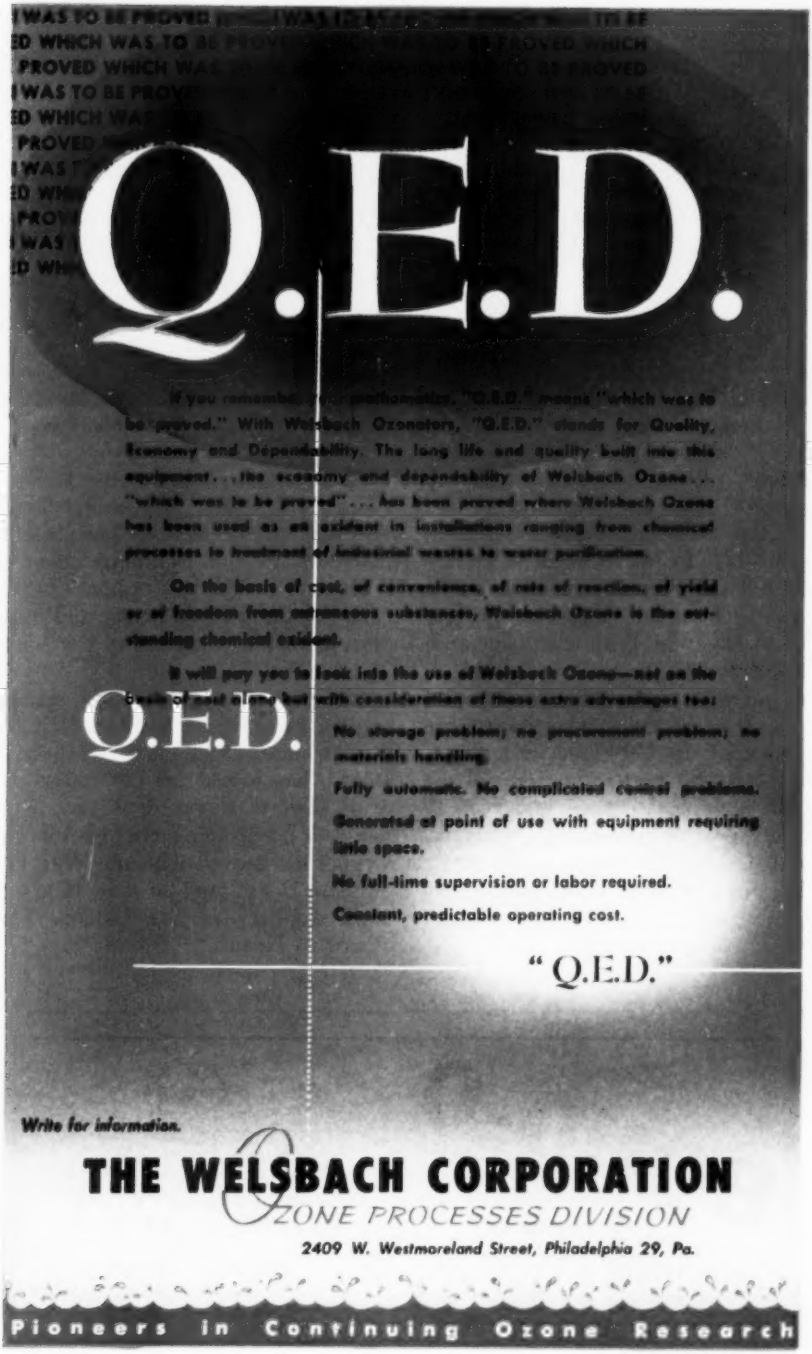
Lack of weather, rather than weather itself, is what people are talking about these days. With no rain, variously, for weeks, for months, for years, much of the nation has had its tongue hanging out further than ever before. Through lowered pressures, lawn sprinkling restrictions, water waste penalties, crop failures, dust storms, forest fires, and a multitude of other discomforts and disasters, more and more people have been learning the hard way all about the wonders of water. And if the direst of our weather prophets are even close to correct in estimating the duration of the present cycle of increasing heat and drydom at several centuries, there ought to be time for even the most unfortunate among us to swing at least one rate increase before it ends.

It is in the Great Southwest (rapidly becoming the Grate Southwest) that the ill wind has been blowing hardest and longest. There, as the years have dried by, appreciation has bloomed in direct proportion to the withering of everything else. At Oklahoma City this year practically the only rain has been that mustered by a group of news photographers assigned to take pictures to illustrate a drought story. In Clovis, N.M., the same sort of frustration afflicted the local weather man when the hail which accompanied the first rain in months destroyed his rain gage as well as breaking 26 of his windows. In Yuma, Ariz., on the other hand, not only no rain, but a main break that forced shutdown of the system for more than a day during 115-degree temperature served as an even ungentler reminder of the importance of water supply. But it has been Texas that has been most profoundly stricken. So profoundly that the Mexican wetbacks have been coming through bone dry. So profoundly that Dallas and Forth Worth have called a truce in their long-time rivalry to get together on a contract with rainmaker Irving Krick. So profoundly, in fact, that the state has begun to contemplate investing more than a billion of those oily dollars in a series of multicity projects to redistribute existing supplies.

Not lack of weather, really, but of what it delivers is what has been causing all the trouble. And once a region finds that its tap on the free distribution system that weather provides is inadequate, its only recourse is to get a bigger one—by prayer, by pipeline, or by precipitation promotion. Water, like weather, is still where you find it, but as of yet, water is a little easier to move.

Blue Mundy was Ambrose on Wednesday, July 15—Ambrose Mundy, that is, vice-president and general manager of the Middlesex Water Co., Woodbridge, N.J., whose home was picketed that evening by fifteen carloads of men, women, and children protesting low pressures in their section of Raritan Township. Some carrying empty water buckets and others placards, the pickets paraded back and forth in front of Mundy's dark and quiet house, asking "What Do We Do in Case of Fire?" and claiming to have "No Water!" What was behind the demonstration other than a noticeable drop in pressure during that day is as yet undetermined, but we'd be inclined to suspect that the water company ought to pass the picketing on to someone else. Be that as it may, this must be the first instance in which a water utility executive has been thus belabored for such reason. Blue Wednesday, too, for public relations.

(Continued on page 44 P&R)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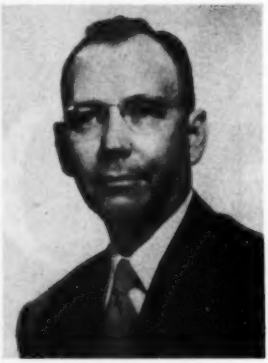
(Continued from page 42 P&R)

Lester Long

A. J. Herrmann



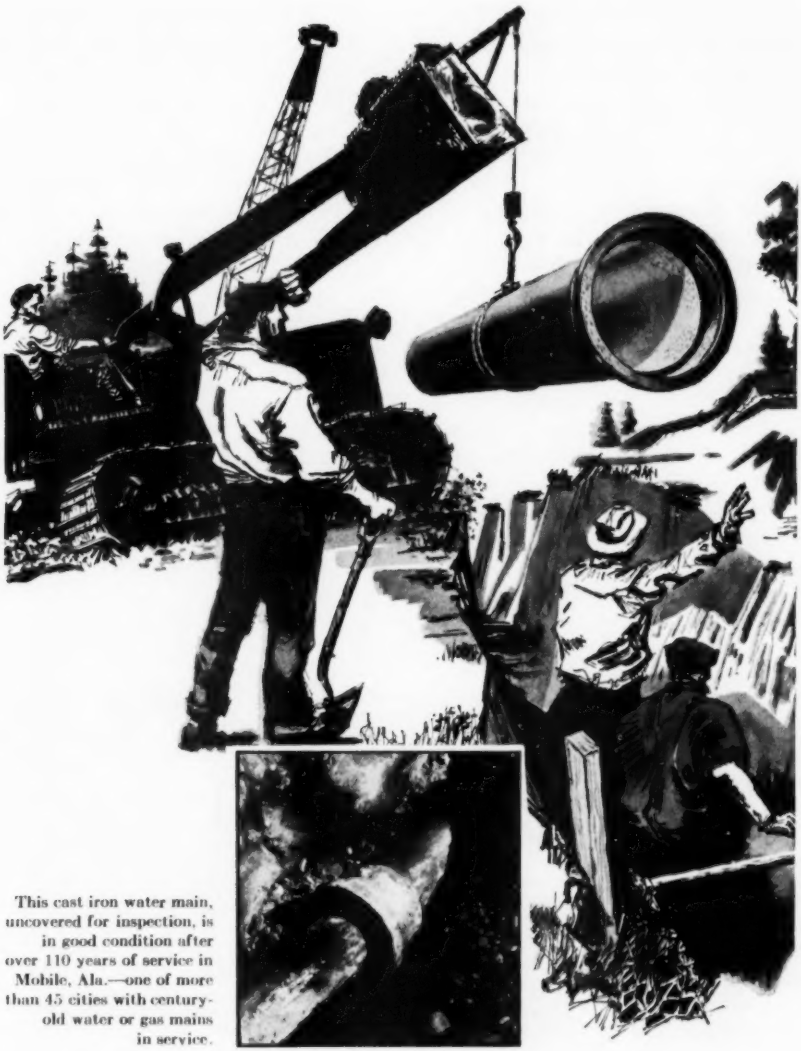
J. W. MacKay

Lester Long, vice-president in charge of sales and secretary of the American Cast Iron Pipe Co., retired on July 12. In his 38 years of service with the company, he held a variety of posts, becoming assistant general sales manager in 1931 and a member of the Board of Directors several times in recent years. He is being succeeded by A. J. Herrmann, who joined the organization in 1914 and was transferred from his post as manager of the Kansas City sales office last year to become assistant general sales manager. The latter post has been assumed by J. W. MacKay, assistant generals sales manager, who was previously assistant southern sales manager.

A. P. Black, head of the Univ. of Florida's Chemistry Dept. and former AWWA president, has been elected president of the Southern Assn. of Science & Industry, a regional organization devoted to the study and development of the resources of the South.

Louis A. Geupel, formerly sanitary engineer for the Utilities Div. of the Defense Department's Munitions Board, has joined the consulting firm of R. Stuart Royer & Assoc., Richmond, Va. A life member of AWWA, Geupel has served with the War Production Board and at one time was chief engineer of the Indiana State Board of Health.

(Continued on page 48 P&R)



This cast iron water main, uncovered for inspection, is in good condition after over 110 years of service in Mobile, Ala.—one of more than 45 cities with century-old water or gas mains in service.

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(Continued from page 44 P&R)

Water supply proposals undergoing study by the New Jersey Legislature include two mammoth projects, one in the north of the state, the other in the south. The northern, or Round Valley, project would contemplate progressive construction of 3 stages, as needed, to develop successively the South Branch of the Raritan River, the Muscenetcong River, and the Delaware River. The project is intended to provide integrated development for a large area, for the legislation permits the sale of water in twelve northern counties of the state by the developing body, which would be the North Jersey Dist. Water Supply Commission, endowed with new and enlarged powers. At present the commission, of which Charles H. Capen is chief engineer, operates the Wanaque Reservoir supply for a group of cooperating municipalities, including Newark, Elizabeth, Bayonne, Kearney, and Montclair.

The southern project contemplates the development of the Wharton tract, comprising the Mullica and Wading Rivers, by the legislatively authorized but as yet inactive South Jersey Dist. Water Supply Commission.

Kenneth A. Steel, formerly service engineer with Industrial Chemical Sales Div., has formed the firm of K. A. Steel Chemicals Inc., with headquarters at 7450 Stony Island Ave., Chicago 49, Ill.

Joseph W. Obreiter has retired as town engineer for Bloomfield, N.J., and is being succeeded by Merrill B. Huber, for the past 20 years assistant town engineer.

(Continued on page 90 P&R)

The Reading Meter

Pumps: *Types, selection, installation, operation, and maintenance. Frank A. Kristal & F. A. Annett. McGraw-Hill Book Co., New York (2nd ed., 1953) 373 pp.; $6.50*

The relatively scant general literature on pumps receives a welcome addition in the form of the second edition of Kristal & Annett's *Pumps*. Neither too technical nor too elementary, the book offers a useful orientation and some guidance to proper pump selection and use. Besides describing the method of operation of such pump types as the reciprocating, centrifugal (volute and diffuser varieties), turbine, and rotary, the book discusses the characteristic features and proper applications of each. Additional chapters treat in detail such specialized types as the deep well, boiler-feed, sewage, and proportioning pumps. The final chapters discuss maintenance, pump priming, and other details of operation, and there is an extended discussion of the determination of economical pipe sizes to which pumps should be connected.

Handbook of Material Trade Names. *O. T. Zimmerman & Irvin Lavine. Industrial Research Service, Masonic Bldg., Dover, N.H. (2nd ed., 1953) 794 pp.; $20*

A purchasing agent's dream, this book is an effective cure for the dilemma posed by requisitions for "Plasgon" cement or "Saran" tubing. Not only does it furnish the name and address of the manufacturer, but it also includes a brief description of the product and its qualities. True, no list of this sort can be perfect, and such items as the U.S. Rubber Company's "Uscolite" and H. N. Hartwell & Son's "Boltaron"—both mentioned in a recent JOURNAL paper on materials for chemical handling equipment (May 1953, p. 473)—will not be found in it. The information that is contained, however, is full and useful, and the publishers advise that periodic supplements will be issued to keep it up to date between editions. A subject classification section facilitates selecting substitute materials for ones that are unavailable or unsuited to specific applications.

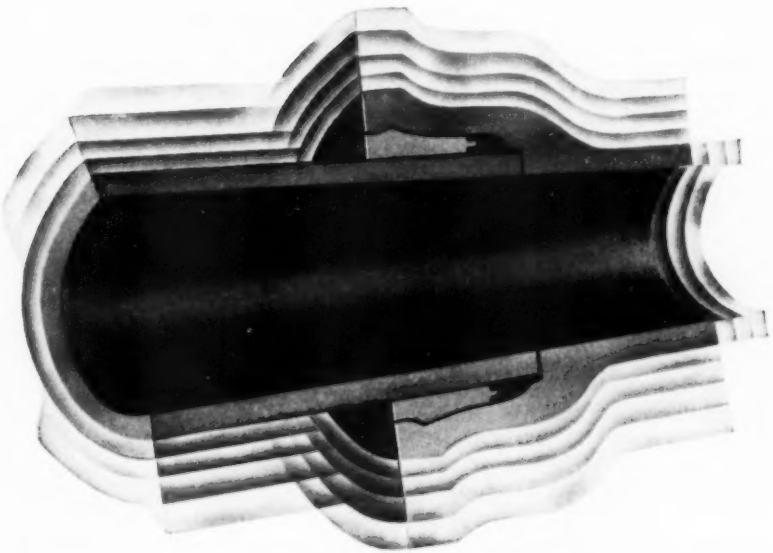
The Industrial Utility of Public Water Supplies in the Middle Atlantic States, 1952. *E. W. Lohr, W. F. White, & N. H. Beamer. Circular 283, Geological Survey, Washington 25, D.C. (1953) 129 pp.; paperbound; free*

This next-to-last of nine reports (see "Reading Meter" for October and December 1952; and January, May, and July 1953) describes the public water supplies in New Jersey, New York, and Pennsylvania. Population served, ownership, sources, treatment, storage facilities, and chemical analyses of raw and finished waters are given for each supply.

Governments of the United States in 1952. *No. 31, State and Local Government Special Studies. Bureau of the Census, U.S. Dept. of Commerce (1953) 49 pp.; paperbound; 30¢ from Government Printing Office, Washington 25, D.C.*

An analysis of the number of various types of local government units in the United States, together with some brief comments on trends in special districts and authorities.

(*Continued on page 52 P&R*)



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The Reading Meter

(Continued from page 50 P&R)

Pretreatment Specifications. *Steel Structures Painting Council, 4400—5th Ave., Pittsburgh 13, Pa. (1953) 11 pp.; paperbound; 60¢ (40¢ to AWWA members)*

The four specifications in this series were prepared by a research committee composed of representatives of 21 organizations, including AWWA, and were approved by the Council as tentative on Mar. 26, 1953. Each specification is printed as a separate booklet, and a folder is provided to house the group. The individual specifications are for: 1. Wetting Oil Treatment; 2. Cold Phosphate Surface Treatment; 3. Basic Zinc Chromate-Vinyl Butyral Washcoat; and 4. Hot Phosphate Surface Treatment.

Ground-Water Resources of the Rapid Valley Unit, Cheyenne Division, South Dakota. *A. J. Rosier. With a section on the surface waters of rapid valley, by L. J. Snell. Circular 201, Geological Survey, Washington 25, D.C. (1953) 32 pp., maps; paperbound; free*

This local study of a watershed in Pennsington County, S.D., is intended as a part of the Geological Survey's program for the development of the Missouri River basin. The area is of interest because high ground water levels have caused much of the irrigated area to be waterlogged. It is found that the leakage from irrigation ditches is responsible. Lining of canals and installation of drains are suggested remedies.

Animal Glue in Industry. *National Assn. of Glue Manufacturers, Inc., 55 W. 42nd St., New York 18, N.Y. (1951) 101 pp.; free*

This monograph reaches us late, as from its title it seemed an unlikely source of information for readers of the JOURNAL, but it does contain a brief section on the use of colloidal animal glue in flocculation and clarification of both raw water and industrial wastes. Either alone or as a supplement to alum, the glue is said to be efficient and economical, forming tough, heavy flocs that settle rapidly. It is also claimed to be adaptable to flotation methods.

The Fluoridation of Domestic Water Supplies in North America as a Means of Controlling Dental Caries. *Report of the United Kingdom Mission, February–April, 1952. Ministry of Health; Dept. of Health for Scotland; Ministry of Housing and Local Govt. (1953) 101 pp.; paperbound; 5 s. (approx. $0.70 U.S.) from Her Majesty's Stationery Office, York House, Kingsway, London, W.C. 2, England*

This carefully documented report of an official fact-finding mission of the British government surveys its findings and states its conclusion in about 20 pages of concise and readable text, relegating detailed findings to fifteen sections of appendix that take up four times as much space. The verdict is clearly and unequivocally in favor of fluoridation, and the report recommends that fluoridation be instituted at several selected communities in the United Kingdom which could serve as study centers or pilot projects.

The Government Corporation: Elements of a Model Charter. *Sidney D. Goldberg & Harold Seidman. Public Administration Service, 1313 E. 60th St., Chicago 37, Ill. (1953) 83 pp.; paperbound; $2.50*

The genesis of this pamphlet was a report developed in 1947 for the use of the Bureau of the Budget in its dealings with government corporations. As it deals with instrumentalities of the federal government, its applicability to those of government subdivisions is of course limited. The charter provisions and explanatory comments are unusually clear for a quasi-legal document.

(Continued on page 54 P&R)

The Reading Meter

(*Continued from page 52 P&R*)

Water Quality Criteria. *Pub. 3, State Water Pollution Control Board, 305 Financial Bldg., 927—10th St., Sacramento 14, Calif. (1952) 512 pp.; paperbound; $3*

This unusually thoroughgoing report was designed to aid enforcement of California's Water Pollution Control Act of 1949, which requires case-by-case evaluation instead of the application of regional or basin-wide standards or zones. As a result, the report has far more than the limited value that might be expected if it dealt only with certain variables within a more rigidly defined frame of reference. Prepared under the direction of Jack E. McKee, associate professor of sanitary engineering at California Inst. of Technology, the report devotes a chapter to the various mechanisms involved in pollution and self-purification, another to a survey of water quality criteria adopted by other agencies, a third to what is called "judicial expression" on the subject, and a fourth to a discussion of quality criteria applicable to the major beneficial uses, ranging from domestic water supply through shellfish culture to water power and navigation. The great bulk of the report, however, is devoted to a discussion of the available information on potential pollutants—their sources, hygienic significance, and toxicity in various concentrations. The literature review for this section alone was exhaustive, and the bibliography of the report as a whole runs for 54 pages and numbers 1,369 items. The final result may certainly be described as a major contribution to the literature and activity of pollution control.

Water Resources of the Rochester Area, New York. *I. G. Grossman & L. B. Yarger. Circular 246, Geological Survey, Washington 25, D.C. (1953) 30 pp., maps; paperbound; free*

Data are given on hydrologic characteristics of the area, surface and ground waters, and public water supplies.

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

SWIMMING POOLS

A Study of Bathing-Water Quality on the Chicago Lake Front and Its Relation to Health of Bathers. R. S. Smith, T. D. Woolsey & A. H. Stevenson. Bathing Water Quality and Health. I. Great Lakes. Environmental Health Center, USPHS, Cincinnati, Ohio ('51). This study of possible relationship between illness occurring among bathers and natural bathing-water quality was undertaken as one of major objectives of tristate survey of L. Michigan waters conducted during summer of '48. Entire project was cooperative one between federal, state, and local health agencies to determine sanitary qual. of shore water with particular reference to bact. qual. of water at public bathing beaches. Epidemiological studies in 2 areas and determination of bathing-water qual. at adjacent beaches in this study were confined to Cook County area. These studies had 2 principal objectives: [1] to obtain dependable data on relationship between bathing-water quality and illness among bathers, which eventually might lead to possibility of delineating acceptable limits of qual. for natural bathing waters (it was realized that before final goal could be reached, series of similar studies would be required in other areas where waters of different qual. and type could be found); and [2] to develop and test methods for gathering reliable data on minor illness and activities from large population at minimum cost. It was concluded that: [1] bathing in L. Michigan shore waters with median coliform density of 180 per 100 ml presents no general hazard to public health; [2] further studies are necessary to determine ranges of water qual. which may be correlated with definite illness hazards to bathers; [3] bathing-water qual. evaluation must be based upon adequate sampling and bact. examn. to obtain understanding of fluctuations in water qual. as well as avg qual. of water over period of time; [4] use of household record maintained on calendar form was highly satisfactory for this type of study; [5] interest of participating population groups was excellent as indicated by return of 78 per cent of completed calendar forms at end of survey; and [6] method of statistical analysis based on comparison of illness experienced within 1 week following swimming on days of markedly varying bact. qual. of water appears to be most satisfactory from standpoint of indicating possible effects of water qual. on health.—*PHEA*

Acceptable Standards for Natural Waters Used for Bathing. C. R. Cox. Proc. ASCE, **77**: 7 (June '51). It is evident that knowledge and technical procedures have not reached level sufficient to permit development of precise quantitative values to measure intrinsic qual. of bathing waters, and, therefore, it is not possible to select definite value that would distinguish between safe and unsafe bathing beaches. Under these circumstances, precise bacteriological stds. cannot be developed, and all available information must be considered in light of properly organized and properly conducted sanitary surveys of each beach. These surveys would include results of bact. examn. of samples of water. Under these circumstances, general administrative guides may be fruitful in encouraging uniformity of practice as long as they are properly utilized without being considered as precise governmental requirements. It is hoped that study of selected beaches on Ohio River and morbidity among bathers utilizing these beaches will furnish information needed for more definite delineation of these problems, and also that more precise analytical methods may be developed to disclose bact. qual. of bathing waters in more definite manner than is now possible.—*PHEA*

Coliform Bacteria and Gram-Positive Cocci in Swimming-Bath Waters. R.

(*Continued on page 64*)

(*Continued from page 62*)

FERRAMOLA & J. ELENA DURIEUX. Rev. Obras San. Nacion [Argentina], **15**:140:173 ('51). Investigation involved examn. of 1,195 samples from 42 swimming pools, some receiving water from River Plate. Coliform bacilli were isolated by inoculation of water sample in MacConkey broth, positive cultures being confirmed by plating out on Levine's medium. Gram-positive cocci were isolated by inoculation of volumes of water samples into azide broth, followed by plating on blood agar and azide agar plates. Colonies growing on these solid media were stained by Gram's method and tested for catalase reaction, to distinguish between streptococci and staphylococci. Water samples were taken at various times, and bathing load and residual chlorine content of water were noted at time of sampling. It was found that coliform and coccal content of samples was higher with high bathing loads and low chlorine residuals. It is not stated whether chlorine was present as free chlorine or combined in chloramines. Coliform bacilli were isolated from 10-ml quants. in 19.3 per cent of samples, and Gram-positive cocci from 60.4 per cent of samples. Both staphylococci and streptococci were isolated frequently when test for coliform bacilli was negative. All samples from baths filled with River Plate water contained coliforms and Gram-positive cocci in 10-ml volumes of water. Total of 987 strains of streptococci isolated and examd., of which 931 could be grouped as enterococci according to Sherman's classification. Staphylococcal strains isolated amounted to 1,241, and 95 of these proved to be coagulase positive within 6 hours. Gram-positive cocci were more resistant than coliform bacilli to chlorination, and authors conclude that coliform bacilli are not adequate indicators of bact. qual. of swimming pool water, but that Gram-positive cocci afford much better index.—*BH*

The Effect of Available Residual Chlorine and Hydrogen Ion Concentration Upon the Eyes of Swimmers. E. W. MOOD, C.

(*Continued on page 66*)

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C. CLARKE & A. GELPERIN. Am. J. Hyg., **54**:144 ('51). This careful study of effect of available residual chlorine and of hydrogen ion concentration of water on eyes of swimmers was undertaken at Yale Univ. with cooperation of university swimming teams. Objective observations of eyes were made and subjective sensations of swimmers were recorded during period of 24 hr after swimming for about 11 min. General chemical and physical state of water was excellent. Its effect on eyes was tested under 4 different conditions—pH 7.0, total available residual chlorine 0.05 ppm and 0.50 ppm; pH 8.0, total available residual chlorine 0.05 ppm and 0.50 ppm. Results were that slightly larger number of sensations of eye irritation followed increase of residual chlorine from 0.05 to 0.50 ppm but that increase in hydrogen ion concentration from pH 8.0 to pH 7.0 had even greater effect on eyes. Analysis of objective data revealed no significant changes due to varying conditions of water. —*BH*

Ozone Sterilization of Swimming Pools. F. D. BROWNLIE. .Munic. Util. (Can.), **90**: 6:60 (June '52). Installation at Coatbridge, Scotland, designed to circulate 150,000 gal in 4 hr, consists of basket type strainer with quick-release cover, pumps, reagent-proportioning app., four 8'-diam. vertical pressure filters equipped with steam jet ejector for agitating sand, steam calorifier, and ozone sterilizing equip. and contact chamber. Water withdrawn from deeper part of pool and from scum trough. Suction sweeper used to remove sediment.—*R. E. Thompson*

Irritations of the Eyes Caused by Bathing in Swimming Pools. H. L. SHEIN, L. E. TAMMELIN & B. ZETTERSTROM. Nordisk Hyg. Tidskrift, **32**:112 ('51). Bathing water with high Mg content (70 ppm), low Ca content (4 ppm), and pH 9.5–10 caused swelling of conjunctiva and subconjunctival hemorrhages in only 1 out of 35 persons, although its content of free Cl_2 was over 2 ppm. Hemorrhages were found in 4, and swelling in 17 out of 42 persons after bathing in water with 8 ppm of Mg, 29 ppm of Ca, 2.1–2.5 ppm of free Cl_2, and pH 8.7. After bathing in water with 18 ppm of Mg, 41 ppm of Ca, and pH 7, 22 out of 70 persons showed hemorrhages, and 8 of them swellings, in spite of Cl_2 content being only 0.25 ppm. High Mg, low Ca, and high pH were insured by filtering water through alkaline ion-exchange filter made from dolomite.—*PHEA*

Investigations Into Swimming-Bath Water Treatment. S. G. BURGESS, D. BURNS & C. W. TIDY. J. Roy. San. Inst., **73**:123 ('53). Purpose of investigation was to ascertain how efficiency of some older plants for treatment of swimming-pool water could be improved at small cost. On investigation into cause of loss of free chlorine, it was considered that action of sunlight is most important factor. It was shown that, when water became devoid of free chlorine, bacterial contamination in form of fecal coli organisms soon became apparent. To avoid this condition, following methods were proposed to increase chlorine input: [1] injection of chlorine solution into suction side of pump; [2] adjustment of sulfuric tube of some chlorinators; [3] maintenance of chlorination during sweeping of pool and washing of filters; [4] use of manifolds so that individual chlorine cylinder output is only 1 lb/hr. Following suggested to insure more uniform concentration of chlorine: [1] use of suction sweeper lines and scum channels for introduction of chlorinated filtered water; [2] introduction of subsidiary circulation from shallow to deep end. It has been shown that, owing to increased chlorine input, small amounts of nitrogen trichloride are formed at point of injection of chlorinator, but that this is rapidly hydrolyzed in pool except under conditions of very high chlorine residuals or heavy bathing load. However, above suggestions assist by avoiding high concentrations of free chlorine at shallow end. It has been shown that high albuminoid content is not necessarily associated with lack of free chlorine residual, poor clarity, or bacteriological impurity. Simple, cheap, and effective plant for alkalinity pH control is described. Aerator is useful to increase oxygen content to saturation and to remove carbon dioxide to some extent.—*PHEA*

Swimming-Pool Classification Program in West Virginia. R. S. JACOBSON. Pub. Health Rpts., **67**:899 ('52). After 2 yr of experience in operating swimming-pool classification program on trial basis, West Vir-

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ginia Dept. of Health reports following results and conclusions: [1] Interest and cooperation of local sanitarian are necessary to success of program. [2] Free chlorine has been verified as better disinfecting agent than combined chlorine. [3] Number of fill and draw pools has been reduced 48%. [4] Number of Class AA and Class A pools has been increased 39%. [5] Number of Class C pools has decreased 29%. [6] Interest and cooperation of pool owners and operators have been very good. [7] Results obtained indicate that program is worth while, and it is planned to continue it within limits of existing facilities.—*PHEA*

Investigations on the Applicability of a Quaternary Ammonium Compound (Cetylpyridinium Chloride) for the Disinfection of the Water of Indoor Swimming Pools. K. SKADHAUGE & J. FOGH. Nordisk Hyg. Tidskr. (Norway), **1952**: 9, 10: 255. Water of indoor swimming pool of 31-cu m capacity was treated with 6.2 l of 10% proprietary preparation of cetylpyridinium chloride (**I**) so as to give final concentration of 20 ppm. Scum appeared on surface and water became cloudy; after 3 days water became clear and sediment of textile fibers, lime and kieselguhr formed on bottom. Samples of water taken daily for 7 days and cultured in lactose-peptone water showed no growth; *Pseudomonas pyocyanea* was found in samples taken between 8th and 11th days. Pool was used during period by 66 persons, who complained that water felt greasy and that sides and bottom of pool were slippery. Pool was emptied, cleaned, and refilled; **I** was then added in concentration of 20 ppm; *Ps. pyocyanea* was present in samples taken 30 min and 3 days later. Pool was then refilled and water treated by filtration and chlorination only for 16 days until water became apparently sterile; **I** was then added in same concentration and *Ps. pyocyanea* reappeared in the samples. **I** became adsorbed on filters and had adverse effect upon their action; rate of flow of water through them was

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reduced and sediment accumulated in bath. Lab. experiments carried out with sand filter and few liters of water showed that concentration of I fell after filtration, so that water lost its disinfectant properties. Time of filtration was greatly prolonged and several washings were necessary before sand could be freed from I. Results show that I is not suitable agent for disinfection of swimming-pool water.—*BH*

POLLUTION CONTROL

Progress in Water Pollution Control. C. E. SCHWOB & L. B. DWORSKY. Pub. Health Rpts., **67**:1080 ('52). Progress of control programs and activities since passage of Water Pollution Control Act in '48 is clearly and concisely presented. Through Div. of Water Pollution Control of U.S. Public Health Service in Washington, together with states, interstate agencies, municipalities, and industries, water pollution data on 226 river basins were collected, assembled, and analyzed during '49 and '50. Data indicated that by July '50 more than 22,000 sources of pollution in U.S. were discharging wastes into rivers and lakes. It is estimated that $9-12 billion in public and private investments will be required during next decade to provide adequate collection and treatment facilities to meet these needs and to allow for future growth and expansion. Although act provided for loans to municipalities for assistance in construction of needed abatement facilities, no funds have been made available for this purpose. Report cites evidence of successful approach to many pollution problems. Public interest has been aroused through publication and distribution of drainage basin reports. Uniformity of state water pollution control laws and policies is beginning to take shape, patterned, in varying degrees, after suggested state water pollution control act developed by USPHS and endorsed and recommended by Council of State Governments. Cooperative solution of interstate pollution problems has been approached through development of formal interstate compact groups and, where compacts do not exist, organization of regional pollution control councils. State water pollution control agencies have increased number of their professional personnel 71% over total for '49. Increased field activity has required new or expanded laboratory facilities in 19 states and increased lab. equipment in 25 others. One of greatest needs expressed by state control agencies was that of obtaining additional information on location and strength of industrial pollutants and their effect on receiving waters. Technical advisory services are provided by USPHS to industry groups, states, interstate agencies, and others needing assistance in pollution problems. Complexity of problem of industrial-waste control resulted in organization of National Technical Task Committee on Industrial Wastes in '50 at invitation of surgeon general. Composed of 57 members representing 36 major industrial categories, this group seeks to stimulate and assist in study and development of known practical methods for control of industrial pollutants and encourage their use. New Environmental Health Center research facility is nearing completion at Cincinnati, where complex and scientific research activities covering many pollution control problems are in progress. Despite these major accomplishments, progress hoped for at time water pollution control program was developed has not been completely achieved. It is estimated that, for sewage treatment alone, annual rate of construction nearly three times that attained in '51 will be required over next decade in order to eliminate backlog of treatment plant projects and meet current needs as they arise. There exist problems of expanding knowledge of effective treatment methods for many new pollutants, both at source and in connection with taste and odor control in public water supplies. USPHS feels that continued cooperative efforts on part of states, interstate agencies, industry, and municipalities will spell success for federal government's water pollution control program.—*PHEA*

Pollution Control Through Mechanism of Classes and Standards. A. F. DAPPERT. Sew. & Ind. Wastes, **24**:313 ('52). In any pollution abatement program, it is necessary to establish some system of classification and standards as basis for deciding on degrees of treatment which must be achieved at waste sources. In order for adopted classes to be useful in guiding sound engineering judgment, they should be based on best usage of waters in public interest and provide enough classifications to fit conditions for which any stream may be used. Also, there should be

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quality standards set up for each class though they should be applied only after waste effluent has been dispersed in stream, and only where there is valid justification should they be expressed quantitatively. Except when designing or approving treatment facilities, standards should not be set for effluents. Important problem encountered in classifying streams is difficulty which public has in understanding and interpreting classes in view of fact that there is usually not much difference in degree of treatment required for discharging into streams of different classes. **Discussion.** E. SHERMAN CHASE. Unless variations in stream flow, seasonal effects, and other significant factors are considered when establishing standards, much engineering judgment must still be exercised in applying them. Considering number of points at which samplings and analyses are required, it is questionable whether benefits to be gained by classifying all waters in state are worth time and cost. Finally, there is danger that any classification system based on arbitrary standards and having force of law represents further step towards government by promulgation of administrative regulations.—*PHEA*

Stream Pollution by Coal Mine Wastes. H. F. HEBLEY. Mining Eng., **5**:404 ('53). General description of nation's water resources, touching upon phenomenal growth in water supply demand and emphasis on problems facing coal industry as to acid mine water drainage dischgd. from active and abandoned mines, and as to suspended solids dischgd. to stream system from wet coal prepn. plants. Stream poln. from any cause merely one factor in comprehensive problem of water supply in modern times. Domestic water consumption now augmented by large number of previously nonexisting industries. Cited are numerous interesting instances of industrial drawdown partially or completely depleting normal ground water supply of domestic users. Typical interstate agreements for control of water resources in

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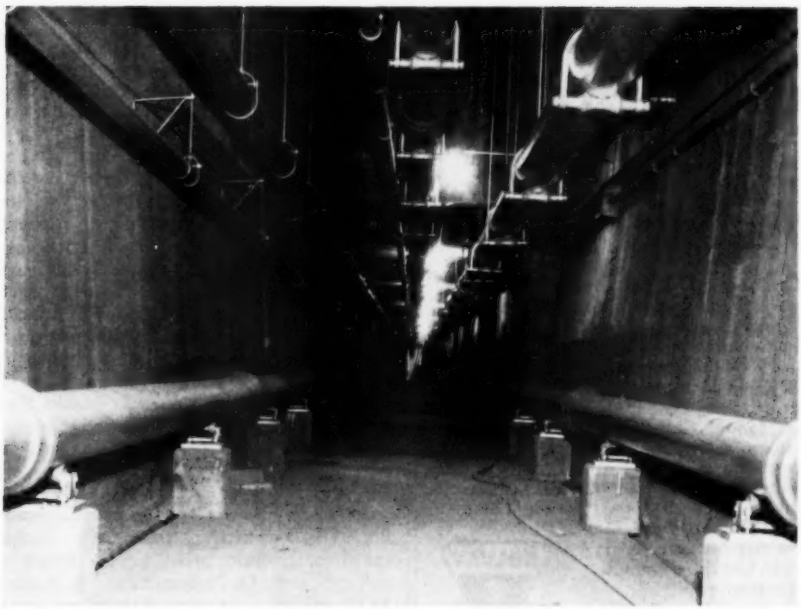

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Delaware, Potomac, and Ohio river basins. Many aspects of problem, some conflicting, include: flood control, power generation, land reclamation, domestic and industrial supply, watershed management, inland and tidal waterways, and stream poln. control. Widespread water demands necessitated priorities, highest assigned to supplies for municipal and domestic purposes. Principal sources of poln. are: domestic sewage; soil solids eroded by annual runoff; and trade wastes, organic and inorganic. Organic trade wastes include those from packing houses, food-processing plants, pulp and paper mills, cheese and butter factories, and beet sugar industry. Inorganic trade wastes include pickle liquor (steel), brines (wells), acid water drainage (coal mines) and metal-finishing liqs. Interaction between wastes illustrated by sewage and acid mine drainage. Latter stops putrefactive process until diluted and alkalinized by downstream tributaries. Biological decomposition processes in stream described and O_2 requirement emphasized. BOD universal measure of poln., except for acid mine drainage. Latter poses many difficulties, particularly handling stupendous vols. of water. Drainage from shallow mines greatly affected by rainfall and depth of earth. Stream pH not a measure of titratable acid; hence, often misleading because buffering action at pH 3.0 allows much alkaline absorption. Role and extent of bacterial activity in acid production and Fe oxidation discussed. Lime, hydrated lime or limestone neutralization of acid mine water impractical from standpoints of vol. and reaction products. Properly designed drainage is possible solution being studied. Suspended solids in washery water, second major difficulty, may be reduced by better design and proper use of elevated settling cones, drag conveyor settling tanks, Dorr thickeners, hydraulic cyclones (Dutch), centrifuges, vacuum filters and thermal dryers, supplemented by lagooning. Industry and municipalities becoming better informed of their obligations through legislation governing water supply and stream poln. Contacts with officials more frequent. Pa. Clean Streams Act ('37, amended '45) defines poln. as dischg. to stream system of noxious and deleterious substances rendering waters unclean to extent harmful or inimical to public health, animal or aquatic life or to use of such waters for domestic supply, industrial pur-

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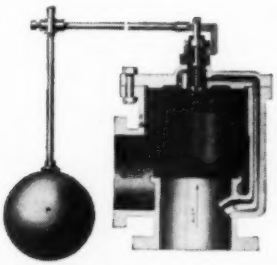

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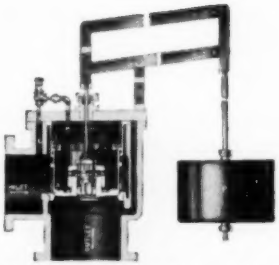

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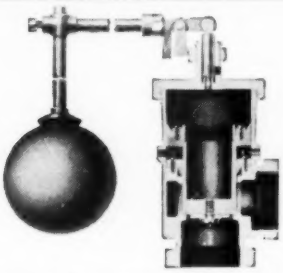
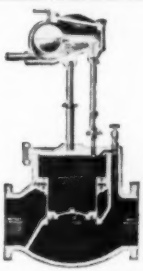


Sizes ½" to 2", cold water, all bronze snap action, pressure 20 psi to 175 psi.



Sizes 3" to 36", cold or hot water, pressure 20 psi.-250 psi.

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poses, or recreation. Industrial wastes construed to mean any liq., gaseous, or solid substance, not sewage, resulting from any manufacturing plant, industry, or establishment causing poln. as defined, and silt, coal mine solids, rock, debris, dirt, and clay from coal mines, collieries, breakers or other coal-processing operations. Law enforcement generally assigned to appointed regulatory bodies vested with wide powers but without checks on their acts or requirements. Thus, not responsible for resulting economic effects. They customarily fix stds. relating theoretical stream conditions to theoretical possible uses. Not required to relate specific requirements to actual conditions and uses. Thus, success of whole control program depends on sagacity of commission members. Latter confronted with wisdom-taxing problems. Cases cited.—*R. E. Noble*

Stream Pollution Problem. FRANK COOGAN. Louisiana Conservationist (Jan. '52). Three general areas of cane sugar production in Louisiana are cited. Pollution problems associated with operation of sugar factories in these areas have been influenced by growth of towns around industries, drainage characteristics of bayous, improvements in factory operations, land available and suitable for impoundment of wastes, mechanical harvesting of cane, and weather conditions. Louisiana Wild Life and Fisheries personnel are engaged in program of surveying stream conditions before, during, and after grinding season to determine effect of grinding operations on water in streams. Two known methods of reducing pollution in streams are: [1] to reduce rate of flow from sugar factories to streams by impoundments; and [2] to provide additional amounts of fresh water in receiving streams.—*PHEA*

Some Aspects of Pollution Control in Tidal Waters. K. E. MILLS. Sew. & Ind. Wastes, **24**:1150 ('52). There is no easy answer to situation as complex as that of stream and tidal water pollution. Consid-

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eration that should receive first attention in evaluating effects of such pollution is: "In what practical sense is condition of affected stream less satisfactory than it was before?" Involved studies of all living forms present in water, together with their seasonal and locational variations, may lead to expensive and academic channels of investigation without result bearing directly on pollution problem. As approach to biological field studies, fish life should be chosen as major index of effect, with emphasis being on fish population. All major phases of industrial water pollution abatement can be combined into program that directs progress of understanding and control in logical sequence. Suggested program is outlined.—*PHEA*

Discharge of Sewage and Industrial Wastes to Estuaries. B. A. Southgate & W. S. Preddy. J. Roy. San. Inst., **72**:424 ('52). By recent legislation, river boards may, under certain conditions, fix standards for quality of polluting liquors which are to be discharged to estuaries. It is therefore important that information should be obtained concerning effects of such discharges on estuaries, where conditions are much more complicated than they are in fresh-water stream flowing in one direction. This paper is divided into several sections, each dealing with different aspect of subject. *Formation of mudbanks.* Occurrence of mudbanks in certain estuaries has sometimes been attributed to pollution by sewage or other organic matter. Large mudbanks, however, frequently occur in estuaries free from serious pollution, and conclusion reached after extensive survey of Mersey estuary was that discharge of crude sewage had not significantly affected accumulation of mudbanks. *Current system.* Polluting matter discharged to estuary oscillates up and down with tide. Method which has been developed for calculating movement of water in estuary, and hence distribution of effluent, is based on measurements of salinity of water at half tide at fixed points. *Concentration of dissolved oxygen.* In many estuaries in Great Britain, content of DO is high at both fresh-water and seaward ends, but, because of pollution, is low in intermediate region where oscillatory movement of water occurs. Presence of DO is of importance not only for migratory fish but also to prevent development of anaerobic conditions and production of hydrogen sulfide, which may cause nuisance. Survey of Thames estuary, now in progress, has as one of its objects determination of relative importance of various factors, such as temperature, rate of flow of fresh water into estuary, and wind velocity, in influencing concentration of DO. *Fisheries.* At present comparatively little is known about ways in which fishery may be damaged. Fish may be asphyxiated if content of DO falls below certain value, or they may be killed by directly poisonous substances; in addition, polluting material may affect food supply of fish or may drive fish away to cleaner waters. Pollution of estuaries may affect shellfish by introducing directly toxic substances or by changing nature of bottom by deposition of sludge or mud; in addition, shellfish may ingest pathogenic bacteria and so become unsafe for food unless they are first "purified" in sterile salt water. *Plants and invertebrate animals.* Work done during survey of Tees R. showed that fall in numbers and species of plants and invertebrates which occurred in middle reaches of estuary was due mainly to natural variations in salinity and not to pollution. *Treatment of polluting liquors discharged to estuaries.* In some estuaries, damage to fisheries may be due to discharge of particular substances in trade waste waters, but, in others, it is discharge of oxidizable matter, including constituents of sewage, which causes pollution. To reduce pollution of second kind it may not be necessary to produce effluents of quality that would be required for discharge to fresh-water stream, and important feature of required treatment might be that it would remove great weight of oxidizable material per day at as low cost as possible. Under these conditions, biological filtration at high rates or anaerobic digestion might be suitable.—*BH*

"Polluted" Water From the Leading of Igneous Rock. R. S. Ingols & A. T. Navarre. Science, **116**:595 ('52). Made curious by occurrence of fixed nitrogen in mountain stream 2,500 ft above sea level, authors investigated series of igneous rocks for presence of fixed nitrogen using method of "leading" crushed rock with water and analyzing solution. Series contained weathered, partially weathered, and unweathered granite and granite-gneiss, as well as piece of fresh Hawaiian basalt for comparison.

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Tests were made for pH, carbonate, nitrate, ammonia calcium, magnesium, and chloride. It was found that rate of weathering did not correlate with fixed nitrogen value, but that all igneous rocks yield soluble substances in approximately same amounts. Conclusion is warranted that concentration of soluble compounds in spring water or surface water which has chance to flow slowly over granite is determined by rate of rock weathering. In areas where rapid weathering occurs, nitrogen determinations for indication of human pollution cannot be used.—*PHEA*

The Pollution of the Bzura River. IRENE CABEJSZEK, ZBIGNIEW MALANOWSKI & STANISLAW WLODEK. Gaz, Woda i Tech. Sanit. (Poland), **26**:162 ('53). During June 19–27 and Nov. 5–10, '51, survey was made of pollution of Bzura R., tributary to Vistula R. Samples were collected for bacteriological and biological examinations and physicochemical analyses from 28 stations along 155-km stretch of river. Purpose of November survey was to determine effect of discharge of wastes from 4 beet sugar processing plants, which were in operation at that time. Other industrial plants located on watershed and discharging wastes to Bzura R. included 2 chemical plants, pharmaceutical plant, 2 tanneries, and textile plant. In addition, sewage wastes are discharged from communities along river. Acid conditions are produced near headwaters of river and continue for stretch of approximately 30 km. In this zone no biological organisms were found, although there was evidence of bacteriological pollution. During summer months highest 5-day BOD was 10 ppm, whereas in November, with sugar plants in operation, BOD increased to 99.6–108 ppm. As a result of pollution at headwaters of Bzura R., recovery does not take place until approximately half of length of stream has been traversed (75 km). Recovery is somewhat slower during colder months. During last 75 km, before confluence with Vistula, BOD does not exceed 10 ppm, and oxygen satura-

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tion value ranges from 40 to 137% during summer and averages about 65% during colder months. Authors suggest that municipal wastes should receive some treatment before discharge to river and that special studies be made of industrial plant wastes to provide pretreatment before discharge.—*C. P. Straub*

Regularities in Growth of Saprophytes During Self-Purification Processes in Polluted Streams. E. V. DIANOVA & A. A. VOROSHILOVA. Mikrobiologiya, **21**:311 ('52). Self-purification of polluted streams follows curves closely resembling curves of bacterial growth in favorable media and with like seasonal changes. Chem. data such as BOD and the mineralization of org. compds. give accurate indications of rate of self-purification and offer means of checking bacterial growth curves or max. points on such curves. —*CA*

Monitoring of Waters for Radioactivity. B. L. ROSENTHAL. Sanitalk (Mass. Dept. Public Health), **1**:15 (Nov. '52). Program was begun early in '51 at Lawrence Expt. Sta. for routine monitoring of certain water supplies for radioactivity. This was done to determine normal radiation background of waters in state as well as to detect possible excessive radiation in water caused by improper disposal of wastes containing spent radioisotopes. Having background radiation measurements is of assistance in civil defense disaster caused by atomic explosion. Article gives description of apparatus used, method of obtaining background radiation information on water supplies and detailed method of making determination. It was interesting to note that background radiation was affected by certain atomic explosions which took place in Nevada. [*Cf.* Jour. AWWA, **45**:562 (June '53).]—*PHEA*

Systematic Analysis of Organic Industrial Wastes. H. BRAUS, F. M. MIDDLETON & C. C. RUCHHOFT. Anal. Chem., **24**:1872 ('52). Approach to systematic method for analysis of organic industrial wastes and waste effluents is based on separation of groups of organic compounds by virtue of differences in solubility. Liquid-liquid extraction is employed. Saturation of aqueous phase with sodium chloride increases efficiency of recovery. Further separation and identification are achieved by use of distillation, infrared analysis, and other organic analytical techniques. These methods have been applied to 5 organic wastes, representative of petroleum industry, synthetic rubber industry, naval stores, coke and steel industry, and synthetic chemicals plant. With procedure described, neutral, phenolic, acidic, and basic components were separated and estimated on all of these wastes. This separation and study of organic components of waste are important in determining possible treatment and pollution abatement procedures and for solving taste and odor problems in water purif.—*PHEA*

Color in Industrial Wastes. III. Color of Suspended Solids and Applications for Waste Color Characteristics. W. RUDOLFS & W. D. HANLON. Sew. & Ind. Wastes, **24**:1502 ('52). Study was made for purposes of [1] developing method for expressing effect of suspended matter on color characteristics of industrial wastes, [2] using

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industrial-waste light absorption properties for calculating concentration of industrial wastes in stream waters, and [3] investigating methods for projecting industrial-waste color characteristics to stream conditions. Method is presented for expressing color characteristics of industrial-waste suspended solids in terms of visual hue and degree of light absorption effected solely by suspended matter. Principle of Beer's law was adapted to light absorption properties of polluted stream waters for purpose of calculating concentration of two or more contaminating wastes. Direct projection of industrial-waste color characteristics to actual stream conditions is not feasible. However, these color characteristics may be extended to longer light absorption cells which are more suitable for stream water standards.—*PHEA*

Stream Protection. A. Joszt. Gaz. Woda i Tech. Sanit. (Pol.), **26**:21 ('52). In addition to its natural flow, stream also receives domestic sewage and industrial waste flows. Official purpose of stream protection is to control discharge of waste materials into stream so as not to exceed its self-purification capacity. Wastes come from two main sources: domestic sewage and industry. Former does not vary markedly from municipality to municipality; latter varies considerably, depending on size of industry, manufacturing process, degree of pretreatment provided, etc. It is reported that domestic sewage flows will amount to 60–250 l per day per person, varying with environmental and cultural habits of people, and will contain approximately 35 g of grease per person per day (which is in accord with Russian and German data). In addition, solids removed from sewage, when digested, will produce about 14 l of methane gas per person per day. Care must be taken in discharge of industrial waste to prevent discharge of toxic elements. Author describes steps that have been taken in Upper Silesia in coping with problem of stream

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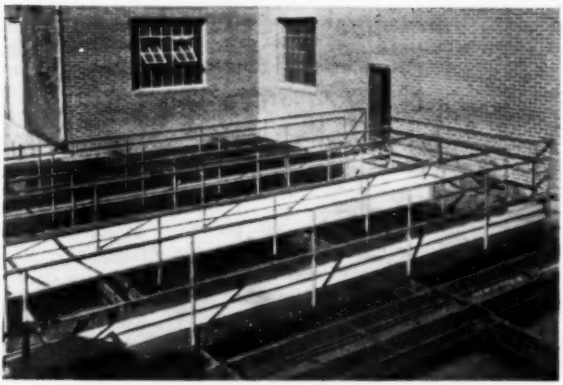
Photo courtesy City of North Kansas City, Missouri



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Water Analysis Report Before and After Conditioning

			PPM as	Raw Water from wells before aeration	Precipitator effluent (unfiltered)
CATIONS	Calcium	(Ca++)	$CaCO_3$	145	55
	Magnesium	(Mg++)	$CaCO_3$	103	75
	Sodium	(Na+)	$CaCO_3$	108	105
ANIONS	Bicarbonate (Alkalinity)	(HCO_3−)	$CaCO_3$	190	42
	Carbonate (Alkalinity)	(CO_3−−)	$CaCO_3$	0	24
	Hydroxide (Alkalinity)	(OH−)	$CaCO_3$	0	0
	Chloride	(Cl−)	$CaCO_3$	35	35
	Sulfate	(SO_4−−)	$CaCO_3$	146	139
	Total Hardness		$CaCO_3$	248	130
	Alkalinity A (Methyl Orange)		$CaCO_3$	190	66
	Alkalinity B (Phenolphthalein)		$CaCO_3$	0	12
	Free Carbon Dioxide		CO_2	16	0
	IRON (total)		Fe	5.0	0.1
	Silica		SiO_2	16.8	13.0
	MANGANESE		Mn	0.2	0.0
	TURBIDITY (after shaking)			50	3
	Fluorides		F	0.5	0.4
	Color			Turbid	5
	pH			7.3	9.5
	Total Hardness (as $CaCO_3$)		Result in grains per U.S. Gal.	15	7.6

PERMUTIT® WATER CONDITIONING HEADQUARTERS FOR OVER 40 YEARS

(Continued from page 84)

protection. Committee comprising interested governmental and provincial groups has been activated to study problem. One of its functions is to determine nature and amount of waste being discharged from some 800 industries in area. To date about 200 of these have been examined and studied. Expert committee makes recommendations for alleviation of waste problem by recommending recovery, change in process within industry, waste treatment, etc.—*C. P. Straub*

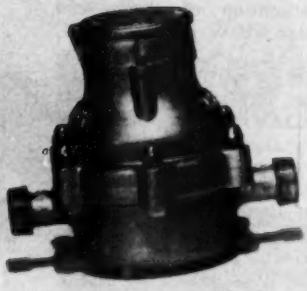
BACTERIOLOGY

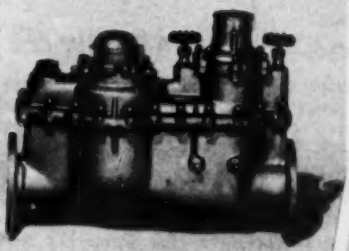
Conditions Affecting the Growth of *Bacterium coli* on Bile Salts Media. Enumeration of This Organism in Polluted Waters. L. A. ALLEN, S. M. PASLEY & M. A. PIERCE. J. Gen. Microbiol., 7:3–4:257 (Nov. '52). Direct count of *Esch. coli* on solid bile salts media at 44°C is affected by number of conditions. Quite apart from variations between different brands of bile salts, excess of any particular one may be inhibitory. Phosphates were also found to reduce yield of colonies. These effects were more pronounced in cells attenuated by prolonged immersion in water. Tests were made to see whether cells attenuated by period of suspension in water could be so resuscitated by preliminary incubation in nutrient medium that they became more resistant to inhibitory action of bile salts and to high temperature of incubation. Time for resuscitation must be no longer than minimum time before actual proliferation of cells commences, and authors chose time of 1 hr [but it is submitted that this is almost impossible to assess, particularly with mixed bacterial flora found in polluted water samples]. It is pointed out that, with increasing periods of immersion, decreasing proportion of cells are capable of being resuscitated before proliferation of some cells begins. This preliminary resuscitation treatment is suggested as technique for obtaining, subsequently, direct colony count of *Esch. coli* at 44°C in polluted waters.—*BH*

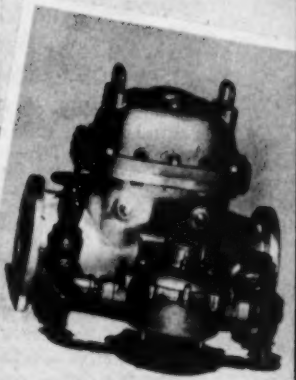
Some Factors Affecting the Viability of Fecal Bacteria in Water. L. A. ALLEN, S. M. PASLEY & M. A. PIERCE. J. Gen. Microbiol., 7:1–2:36 (Aug. '52). Effect of various conditions on rate of death of *Esch. coli* and *Str. faecalis* in dilute buffer solutions was followed by making colony counts at intervals during prolonged periods of incubation and then constructing mortality curves. Factors studied were pH value, oxygen tension, concentration of nutrient material, and age of culture at time of immersion in water. Strains of bacteria used were freshly isolated from sewage or river water and were typically *Esch. coli* type I and *Str. faecalis*. Very dilute phosphate buffer solution was used as suspending fluid so that pH value remained virtually constant throughout course of each experiment. Survival curves for *Esch. coli* and *Str. faecalis*, when plotted in logarithmic form, were characteristically of different shapes; that of former organism approximated to straight line and curve of latter organism sloped very gently at first and then quite steeply. Rates of death determined at different pH values showed same trend for both organisms; viability is greatest at pH 5.0–5.2, least at pH 6.1–7.1, and intermediate between these extremes at pH 7.6–7.7. Effect of oxygen tension showed marked difference of behavior between these 2 organisms; *Esch. coli* died much more rapidly under anaerobic than under aerobic conditions, whereas, with *Str. faecalis*, no significant difference was observed in rates of mortality under these conditions. Observations on rates of growth when small concentrations of nutrient material were present in water gave some very important results. For *Esch. coli*, lowest concentration of broth in which substantial growth occurred was 10 ppm, which corresponds to content of 0.03 ppm Yeastrel, 0.2 ppm peptone, 0.05 ppm glucose, and 0.1 ppm Lemco. Expressed in terms of chemical aanlysis, this dilute broth had 5-day BOD (at 18.3°C) of 0.26 ppm, and oxygen-absorbed figure from acid permanganate in 4 hr at 26.7°C was 0.08 ppm. Compared with concentration required for *Esch. coli*, nutrient content of broth had to be increased 50-fold before definite growth of *Str. faecalis* took place. It was shown that presence of minute quantity of organic matter (less than 1 ppm) may induce profound departure from normal form of mortality curve for *Esch. coli*.—*BH*

Viability of the Anti-Vi Bacteriophage in Natural Aquatic Habitats in Comparison

(Continued on page 88)







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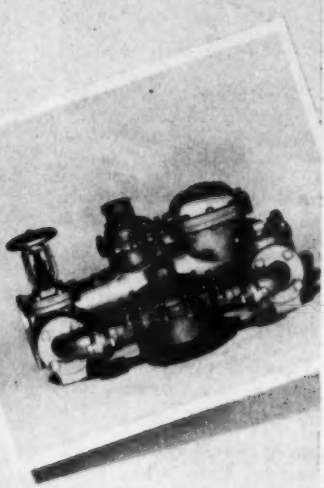

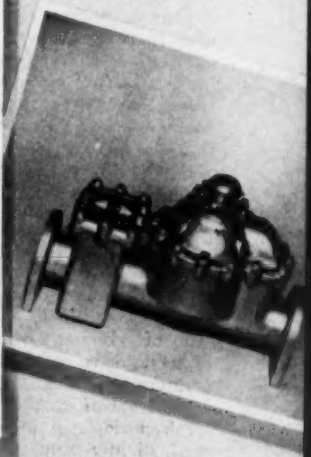

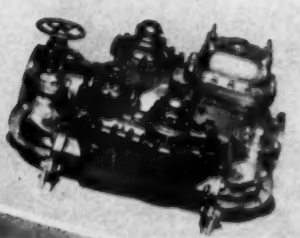

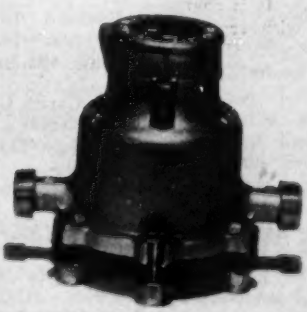

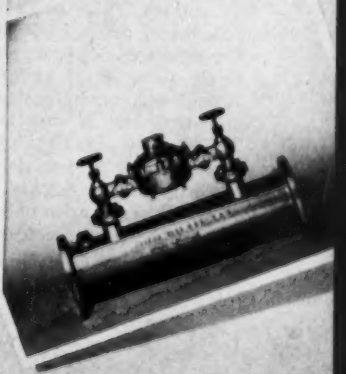

(*Continued from page 86*)

With Viability of Homologous Typhoid Bacteria. W. EMILIANOWICZ. Bul. State Inst. Marine & Trop. Med. (Poland), **4**:342 ('52). Author endeavored to ascertain whether presence of specific bacteriophage would be index of degree of pollution by homologous bacteria. He therefore investigated viability of anti-Vi bacteriophage and homologous typhoid bacteria in various aquatic habitats and at various temperatures (4°C, 22°C, and 37°C). Experiments were carried out in distilled water, physiological saline, tap water, river water, pond water, sea water, sewage, Seitz-filtered sewage effluent. Figures are given for initial bacteriophage and bacterial titers, but results of experiments are not included. In final conclusion author finds that survival of Vi typhoid bacilli is dependent above all on biological properties of water and, in lesser degree, on its temperature. On other hand, survival of bacteriophage depends above all on temperature, and biological properties of water have little effect. No relationship could be found between survival rate of bacteria and that of corresponding bacteriophage, but latter is much more resistant to its environment than former.—*BH*

Investigations Concerning Viability of the Anti-Vi Bacteriophage in the Soil. HALINA WYSOCZYNSKA. Bul. State Inst. Marine & Trop. Med. (Poland), **4**:357 ('52). Aim of this work was to ascertain viability of bacteriophages in soil with regard to temperature and kind of soil. Investigation was carried out of disappearance of specific anti-Vi bacteriophage in 3 different soils—seasand, slightly manured garden soil, and compost soil—at 3 temperatures: 37°C, 20°C, and 4°C. Anti-Vi bacteriophage was used which had been isolated in 1940 during typhoid epidemic in Warsaw. It is characterized by high specificity with regard to Vi antigen. Size of particles of this bacteriophage, determined by means of ultrafiltration method, is 40 mμ. In all investigated soils, at 3 different temperatures, anti-Vi bacteriophage survived to some degree until end of experiments—that is, for 96–122 days. Survival of anti-Vi bacteriophage in soil is dependent on temperature. It perishes most quickly at temperature of 37°C. Contamination of soil with mesophilic and psychrophilic bacteria exerts no influence on viability of anti-Vi bacteriophage. —*BH*

Quantitative Estimation of *Salmonella* in Irrigation Water. S. G. DUNLOP, R. M. TWEDT & WEN-LAN LOU WANG. Sew. Ind. Wastes, **24**:1015 ('52). Quant. method has been developed for estn. of *Salmonella* in sewage-contamd. irrigation water. Of 11 samples of irrigation water, 8 were positive for *Salmonella*. Median value for all 11 samples was 0.9 *Salmonella* per 100 ml. Only 1 of 14 samples of vegetables irrigated with this water was positive for these organisms. Ratios of 225,000 coliforms and 4,800 enterococci to 1 *Salmonella* were computed from median values obtained from water samples. In comparing coliform and enterococcus counts from vegetables subjected to washing and blending, no consistent trend was shown in favor of either method.—*PHEA*

OTHER ARTICLES NOTED

Recent articles of interest, not abstracted, are listed below.

Reservoir Treatment by Improved Methods. R. L. DERBY & F. W. TOWNSEND. Wtr. & Sew. Wks., **100**:211 (June '53).

Use of Diatomite Filters Can Be Economical. E. R. BAUMANN & H. E. BABBITT. W.W. Eng., **106**:526 (June '53).

Air-conditioned Chemical Conveyor Solves Treatment Problem. F. L. ANDREOLI. Wtr. & Sew. Wks., **100**:227 (June '53).

How a Submarine Water Main Was Laid. A. R. MACPHERSON. Pub. Wks., p. 76 (July '53).

Ways to Make Pipe Finding Easier. G. M. MACLEOD. Am. City, **68**:6:122 (June '53).

Postcard Billing for Water and Sewage Utilities. D. L. MAFFITT. Wtr. & Sew. Wks., **100**:217 (June '53).

Per Capita Use of Water in Schools. K. S. WISNIESKI & MAX GARBER. Pub. Wks., p. 97 (July '53).

The Teaching of Limnology in the United States. D. G. FREY. Scientific Monthly, **76**:290 (May '53).

New Lifeline for Twelve Thirsty Texas Cities. ANON. Eng. News-Rec., **151**:3:43 (July 16, '53).

(Continued from page 48 P&R)

"Luxurious dissipation" is what Webster refers to in one of his definitions of the adjective "Corinthian," and that's the definition Tom Skinker, St. Louis water commissioner must be endorsing right now, having just okayed the expenditure of $10,000 for the renovation of an 83-year-old standpipe which hasn't been used for the last 40 years. Back in 1870, when it was built, the "Corinthian" referred strictly to the architecture, for the 154-ft tower was then the largest perfect Corinthian column in the world. Now, with the structure long a landmark to the residents of the North St. Louis area which grew up around it, it's a public issue rather than a facility. And, remembering the storm of public protest that arose when one of his predecessors suggested its destruction, Tom didn't hesitate with hush money. As a matter of fact, as far as the water department is concerned, the expenditure can't be considered dissipation at all, but a sound investment in public relations. Taet elefant.

Stanley Eng. Co., consulting firm of Muscatine, Iowa, has opened a branch office at 327 LaSalle St., Chicago 4, Ill. The office will be directed by Frank W. Edwards, formerly director of civil engineering at the Illinois Inst. of Technology.

James G. Baldwin has been appointed Los Angeles district sales manager of the Pennsylvania Salt Mfg. Co. of Washington.

(Continued on page 92 P&R)

From inland reservoir to rugged coast line...

REINFORCED CONCRETE PRESSURE PIPE SAVES MONEY ALL THE WAY!

A section of the pipe line connecting an inland reservoir with Corona Del Mar on the Pacific Coast. For this line, The Metropolitan Water District of Southern California chose Reinforced Concrete Pressure Pipe, made by American Pipe and Construction Co. This view shows the installation of 36" Concrete Pipe with the Double Rubber Gasket Pressure Joint

This installation, near Corona Del Mar, California, is only one of thousands where Reinforced Concrete Pressure Pipe has helped to cut over-all cost.

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(Continued from page 90 P&R)

Stout and Gay are the powers that now be at the Clarksburg, W.Va., Water Board—Thurman A. Stout and Henry R. Gay, who took over the positions of General Manager and Chief Chemist of the utility upon the retirement of Scotland G. Highland and Perkins Boynton last May 1. Stout, formerly engineer with the West Virginia Water Service Co., and Gay, who moved up from the position of assistant chemist, are taking over from two real veterans of the field.

In his 45 years with the Clarksburg board (40 of them as an AWWA member), Highland made himself well known throughout the industry for his faithful attendance and close attention at Association technical sessions as well as for his early use of public relations techniques at Clarksburg. Boynton, junior in service by only four years, has earned for himself the title of "Dean of Operators" in West Virginia through his long-time contributions to the advancement of water works practice, which also won him his section's Fuller Award in 1940. Stout men both, and now they can be gay.

Meter readability is said to be aided by a transparent plastic case that can be used to enclose the register and change gears in a clear, nonfreezing fluid. The case is molded of Tenite plastic for the Fog-Tite Meter Seal Co., Seattle, which markets the device. The makers claim that their product not only prevents condensation on the register glass but prevents corrosion of the registers. It is suggested, however, that users check with the manufacturer of their meter to determine the suitability of the device before installing it.

David C. Colebaugh Jr., chemist at the Nuchar Research Lab. of West Virginia Pulp and Paper Co. in Tyrone, Pa., has been assigned to the Chicago sales staff of the firm's Industrial Chemical Sales Div.

The Pacific Coast Div. of the Badger Meter Mfg. Co. has been established with headquarters at 2940 Leonis Blvd., Los Angeles 58, Calif., with Ross Burns in charge as western sales manager.

Dearborn Chemical Co. has moved its Eastern Div. from New York City to 1601 Linden Ave. E., Linden, N.J. The new location includes sales, administrative, and warehousing facilities under one roof, and is located near rail and trucking terminals.

Service Lines

The resistance of seven classes of cements to 297 corrosive substances is shown by a chart offered by Corrosion Engineering Dept., Pennsalt Chemicals, 1000 Widener Bldg., Philadelphia 7, Pa.

Plastic pipe fittings made of brass and designed with teeth that grip the pipe wall, as a sleeve is tightened, to make a nonslip joint, are described in a booklet, Bul. AR-200, of the Nelson Foundry Co., 6116 Oakton St., Morton Grove, Ill. The Barracuda Brass Fittings, as they are called, are said to prevent weakening of joints attributable to the cold flow of the plastic.

"Measuring Equipment for Laboratory and Production Testing" is the subject of a 64-page catalog issued by General Electric Co., Schenectady 5, N.Y. Various types of instruments for electrical testing, chemical analysis, materials testing, and other applications are described.

A chlorination control nomogram that relates values of flow and desired chlorine dosages to obtain the chlorine feed rate in pounds per 24 hr is the subject of Keep Sheet No. 21 issued by B-I-F Industries, 345 Harris Ave., Providence 1, R.I.

The new Ratochlor Chlorine Dispenser, Fig. 1050, is the subject of a 12-page catalog, No. 61, of Fischer & Porter Co., 818 Jacksonville Rd., Hatboro, Pa. The dispenser is a solution-feed, dry-vacuum type, and the ten models in the line offer a capacity range of from 0.5 to 1,000 pounds per 24 hr.

(*Continued on page 96 P&R*)

(*Continued from page 94 P&R*)

Oligodynamic purification with silver ions is the subject of some pamphlets offered by American Katadyn Corp., 375 Fairfield Ave., Stamford, Conn. In addition to some circulars describing the equipment, a 12-page booklet describes their bactericidal effect as observed in various tests.

Water and sewage construction projects of the Baton Construction Corp., 1717 Sansom St., Philadelphia 3, Pa., are described in a 6-page folder available on request.

"Instrumentation for Water, Sewage, and Industrial Waste Treatment," a 24-page booklet describing instrument installations and applications in water and waste treatment plants, may be obtained on request to Station 64, Minneapolis-Honeywell Regulator Co., Industrial Div., Wayne & Windrim Aves., Philadelphia 44, Pa. The discussion is well illustrated and references are given to a wide variety of supplementary literature issued by the company.

"Corrosion Resistance of Copper and Copper Alloys" is the title of a newly revised, 28-page booklet, B-36R, being offered by the American Brass Co., Waterbury 20, Conn. A table gives copper-base alloys to 183 corrosive agents.

Dual-purpose pipe couplings intended as a coupling or repair clamp are described in a folder, No. 101, of Morris Coupling & Clamp Co., Dept. J-59, Ellwood City, Pa. Installation instructions, specifications, and prices are given.

A vapor corrosion inhibitor permits packaging of metal replacement and other parts in a paper impregnated with a volatile corrosion inhibitor. A folder describing the Dry Vapor Pack-Velope is distributed by the Industrial Packaging Div., Berlin & Jones Co., Inc., 601 W. 26th St., New York 1, N.Y.

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General Chemical Div.

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General Chemical Div.

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(See Prof. Services, pp. 25–29)

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Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Welsbach Corp., Ozone Processes Div.

Jointing Materials:
Atlas Mineral Products Co.
Hydraulic Development Corp.
Leadite Co., Inc.
Northrop & Co., Inc.

Joints, Mechanical, Pipe:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Dresser Mfg. Div.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Leak Detectors:
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
Dorr Co.
Infilco Inc.
Omega Machine Co. (Div., Builders Iron Fdry.)
Permutit Co.

Magnetic Dipping Needles:
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.
Ford Meter Box Co.
Hays Mfg. Co.
Hersey Mfg. Co.
James Jones Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Smith-Blair, Inc.
Welsbach Corp., Kitson Valve Div.
Worthington-Gamon Meter Co.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Meters, Filtration Plant, Pumping Station, Transmission Line:
Builders-Providence, Inc.
Infilco Inc.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Builders-Providence, Inc.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co., Inc.
Well Machinery & Supply Co.
Worthington-Gamon Meter Co.

Mixing Equipment:
Chain Belt Co.
Infilco Inc.
Walker Process Equipment, Inc.

Ozonation Equipment:
Welsbach Corp., Ozone Processes Div.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Crane Co.
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
Cast Iron Pipe Research Assn.
James B. Clow & Sons
McWane Cast Iron Pipe Co.
Pacific States Cast Iron Pipe Co.
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe Coatings and Linings:
The Barrett Div.
Cast Iron Pipe Research Assn.
Centriline Corp.
Koppers Co., Inc.
Pipelife, Inc.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Universal Concrete Pipe Co.

Pipe, Copper:
American Brass Co.

Pipe Cutting Machines:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pipe, Plastic:
Carlon Products Corp.

Pipe, Steel:
American Locomotive Co.
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Southern Pipe & Casing Co.

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potentiometers:
Hellige, Inc.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Economy Pumps, Inc.
Morse Bros. Mchy. Co.

Pumps, Chemical Feed:
Infilco Inc.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.

Pumps, Diaphragm:
Dorr Co.
Morse Bros. Mchy. Co.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Sump:
DeLaval Steam Turbine Co.
Economy Pumps, Inc.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Layne & Bowler, Inc.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Co., Inc.

Recording Instruments:
Infilco Inc.
Sparling Meter Co., Inc.
Wallace & Tiernan Co., Inc.

Reservoirs, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves; see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Permutit Co.

Soda Ash:
Solvay Process Div.

Sodium Hexametaphosphate:
Blockson Chemical Co.
Calgon, Inc.

Softeners:
Belco Industrial Equipment Div.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon, Inc.
Infilco Inc.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
American Locomotive Co.
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Hays Mfg. Co.
James Jones Co.
Mueller Co.
A. P. Smith Mfg. Co.
Welsbach Corp., Kitson Valve Div.

Storage Tanks; see Tanks

Strainers, Suction:
James B. Clow & Sons
M. Greenberg's Sons
Johnson, Edward E., Inc.
R. D. Wood Co.

Surface Wash Equipment:
Permutit Co.

Swimming Pool Sterilization:
Everson Mfg. Corp.
Omega Machine Co. (Div., Builders Iron Fdry.)
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Pittsburgh-Des Moines Steel Co.

Tapping Machines:
American Locomotive Co.
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.
Welsbach Corp., Kitson Valve Div.

Taste and Odor Removal:
Industrial Chemical Sales Div.
Infilco Inc.
Permutit Co.
Proportioneers, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Turbines, Steam:
DeLaval Steam Turbine Co.

Turbines, Water:
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valve-Inserting Machines:
A. P. Smith Mfg. Co.

Valves, Altitude:
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
James B. Clow & Sons
Crane Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Belco Industrial Equipment Div.
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Davis Mfg. Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
James Jones Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Pacific States Cast Iron Pipe Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Philadelphia Gear Works, Inc.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
Davis Mfg. Co.
Kennedy Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Crane Co.
Davis Mfg. Co.
Mueller Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
James B. Clow & Sons
Crane Co.
Darling Valve & Mfg. Co.
M. Greenberg's Sons
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Waterproofing
Inertol Co., Inc.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
Hellige, Inc.
Wallace & Tiernan Co., Inc.

Water Treatment Plants:
Allis-Chalmers Mfg. Co.
American Well Works
Belco Industrial Equipment Div.
Chain Belt Co.
Chicago Bridge & Iron Co.
Cochrane Corp.
Dorr Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Co., Inc.
Welsbach Corp., Ozone Processes Div.

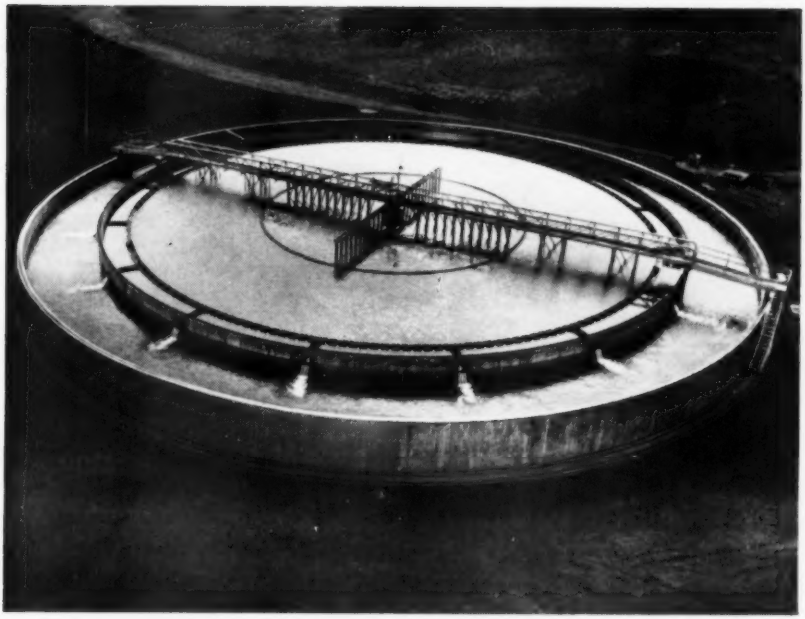
Well Drilling Contractors:
Layne & Bowler, Inc.

Well Screens
Johnson, Edward E., Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

Zeolite; see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1953 AWWA Directory.



Located at Fibreboard Products, Inc., Antioch, Calif., this Clariflocculator treats 14 MGD of San Joaquin River water for process use. A 15' wide annular storage reservoir surrounds the 150' dia. Clariflocculator and a Dorrco VM Pump removes the dense underflow at minimum water loss.

No "Magic Formula" Approach Here...

Supplying 14 MGD of clear, process water for a West Coast Pulp Mill called for more than a "magic formula." Like all well-designed water treatment plants, it called for a detailed analysis of the problem. Raw water composition, rate of flow, results required, and local conditions were all studied before selecting the type of treatment to be used. The most efficient answer in this case was combination treatment with a Dorrco Clariflocculator.

There is no magic formula for every type of water treatment problem . . . no single equipment unit that will give ideal results under all conditions. For a brief picture of the complete Dorr equipment line for both conventional and high-rate treatment, write for Bulletin #9141, The Dorr Company, Stamford, Conn. In Canada: 26 St. Clair Avenue E , Toronto 5.

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Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
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